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14. ABSTRACT
The purpose of this report is to provide access to experimental laboratory data involving human decompression exposures that have not been published and thus are not presently available for analysis by Navy and other researchers. As such, this is only a report of the data, not a write-up of the experiment or analysis. This project was designed to evaluate surface decompression requirements for a variety of dive profiles.

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SURFACE DECOMPRESSION DIVING

DATA REPORT ON PROTOCOL 90-02

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Prepared for

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Surface Decompression Diving

Data Report on Project 90-02

A. Description of Project 90-02

1. Nature of this report

The purpose of this report is to provide access to experimental laboratory data involving human decompression exposures that have not been published and thus are not presently available for analysis by Navy and other researchers. As such this is only a report of the data, not a writeup of the experiment.

This report covers the project entitled "Surface Decompression Diving." It was intended to investigate anecdotal reports of a high incidence of decompression sickness from surface decompression dives, particularly as it might affect tenders. The dives were intended to use only established procedures in the U.S. Navy or Royal Navy diving manuals.

This was carried out in 1990 under protocol number 90-02 and includes results of 94 manned chamber dives exploring various aspects of surface decompression diving. Project 90-02 was approved in June of 1990 by the Naval Medical Research Institute. Principal Investigator was CAPT E.D. Thalmann.

2. Description of the Project

These chamber dive simulations were conducted in the Man-Rated Chamber Complex at NMRI. More details are included in an extract of the original protocol as included in Appendix A.

The types of dives conducted are given here.

U.S. Navy Tables

Surface Decompression on Air

	DEPTH	BOTTOM TIME	SCHEDULE
GROUP 1	60 fsw	180 min	60 fsw / 200 min
GROUP 2	120 fsw	50 min	120 fsw / 60 min

Surface Decompression on Oxygen

	DEPTH	BOTTOM TIME	SCHEDULE
GROUP 3	60 fsw	180 min	70 fsw / 180 min
GROUP 4	120 fsw	50 min	120 fsw / 60 min

Some dives were also proposed using the British Royal Navy sur-d tables, but we have no records of such dives and presume that they were not done. Standard U. S. Navy procedures were used for the decompressions, with the schedules selected in a conservative way.

B. Methods

1. Dives

Extracts from the original protocols are given in Appendix A. That contains more details about the methods. A brief synopsis is included here.

Each dive involved 2 or 3 divers and one tender. Divers wearing standard 1/4" wet suits and helmets with demand regulators were compressed to a depth slightly less (3 fsw) than the target depth. This "offset" was added to the computer record when the divers went into the water, and removed at 4 fsw during ascent.

Divers were to alternate between rest and working a bicycle ergometer at 75 watts in 10-min sessions (Annex A says 100 W), each working for approximately half the bottom time. Exercise was to be stopped at least 2 min before ascent.

Water temperature was adjusted as follows, based upon total dive time:

Less than 140 min	60° F
More than 140 min	65° F

Compression rates were to be 30 fsw/min. Decompressions were according to procedures in the U.S. Navy Diving Manual. These are recorded on the log and shown on graphs.

2. Data

Pressures in various chambers were recorded against time by the in-house computer of the MRCC at NMRI. We used a printout of this log to prepare this report. We did not have access to the conventional log; it is archived in the Technical Library. The computer records time in minutes and thousandths of minutes from the time it was started. The time the divers left surface was noted, but it was not normally done at zero time.

In addition to the text log of pressures against time, a x-y plotter shows each dive profile graphically.

Both text and graphic logs have clock times to the nearest second added by hand to all the important points of the dive, such as LS (leave surface), RB or R20 (reach bottom or reach a depth), and RS or R20 (reach surface or reach a depth). These times recorded in the two places were found to match perfectly.

The computer text printouts have many data points that are of little interest and are thus too bulky to include in this report. Accordingly, we have prepared extracts of these logs, which are included in the Results section.

These dives are in the NMRI data base under filenames **nmrasurd.dat** and **nmrosurd.dat** for the sur-d/air and sur-d/O_2 respectively.

C. Diver List

A total of 33 diver-subjects participated in this project. In this report the divers names have been replaced with numbers. A "key" list of names and assigned diver numbers is on file with the original materials, presumably at the library of the Naval Medical Research Center, Forest Glen, MD. Cognizance of the list and materials rests with Ms. Diana Temple at NMRC. This key remains property of NMRC and can be made available to researchers who need it provided they will maintain diver anonymity in any publication of their analysis.

A list of diver numbers according to the dive exposure groups is given below. Diver ID numbers were assigned more or less randomly according to the diver list. If a diver did not complete a dive, due usually to ear clearing or equipment problems, the dive is not included in any of these lists or logs.

"1" series, 60 fsw/180 min with Sur-D/air
"2" series, 120 fsw/50 min with Sur-D/air
"3" series, 60 fsw/180 min with Sur-D/O_2
"4" series, 120 fsw/50 min with Sur-D/O_2

Table I.

Diver#	Dive/series/dive number
1.	SURD103, SURD203, SURD205
2.	SURD101, SURD110, SURD203, SURD205, SURD210
3.	SURD104, SURD110, SURD205
4.	SURD201, SURD206, SURD306, SURD404, SURD406
5.	SURD105, SURD206, SURD408
6.	SURD105, SURD110, SURD211, SURD206, SURD306, SURD407
7.	SURD207, SURD211, SURD304, SURD406
8.	SURD103, SURD108, SURD207, SURD208, SURD302, SURD403, SURD407
9.	SURD207, SURD209, SURD302
10.	SURD107, SURD109, SURD204, SURD208, SURD301, SURD407
11.	SURD104, SURD112, SURD209, SURD401, SURD408
12.	SURD105, SURD209, SURD305, SURD403, SURD409
13.	SURD111, SURD210
14.	SURD101, SURD108, SURD204, SURD210
15.	SURD109, SURD211, SURD303, SURD401
16.	SURD301, SURD405
17.	SURD102, SURD301, SURD306
18.	SURD112, SURD302, SURD405
19.	SURD203, SURD303, SURD404
20.	SURD101, SURD111, SURD303, SURD403
21.	SURD304
22.	SURD304, SURD405
23.	SURD305
24.	SURD104, SURD202, SURD305, SURD401
25.	SURD402
26.	SURD107, SURD201, SURD402, SURD409
27.	SURD102, SURD107, SURD402, SURD409
28.	SURD204, SURD404
29.	SURD406
30.	SURD408

continued on next page

31. SURD102, SURD112
32. SURD103, SURD202
33. SURD108, SURD111
34. SURD201
35. SURD202

D. Results

This section contains the results of the dive series. The dives are of 4 types, so are presented here according to the 4 groups:

Group 1, 60 fsw/180 min with sur-d/air
Group 2, 120 fsw/50 min with sur-d/air
Group 3, 60 fsw/180 min with sur-d/O_2
Group 4, 120 fsw/50 min with sur-d/O_2

1. Dive summary

A summary chart of the dive series is shown in Table I.

Table II.
Dive summary

Dive date	Dive ID #	Depth/ Time	# of divers	Diver ID #	DCS	Comments
Dive Group 1. 60 fsw 180 min air dive with surface decompression with air						
Nov06	SURD101.LOG	60/180	3	2, 14, 21	0	
Nov06	SURD102.LOG	60/180	3	18, 28, 32	0	
Nov08	SURD103.LOG	60/180	3	1, 8, 33	0	
Nov08	SURD104.LOG	60/180	3	3, 11, 25	0	
Nov13	SURD105.LOG	60/180	3	5, 12, 16	0	
Nov13	SURD106.LOG		0			Dive aborted
Nov15	SURD107.LOG	60/180	3	10, 27, 28	0	
Nov16	SURD108.LOG	60/180	3	8, 14, 34	0	
Nov27	SURD109.LOG	60/180	2	10, 15	0	
Nov 27	SURD110.LOG	60/180	3	2, 3, 16	0	
Nov29	SURD111.LOG	60/180	3	13, 21, 34	0	
Nov29	SURD112.LOG	60/180	3	11, 19, 32	0	

Dive date	Dive ID #	Depth/ Time	# of divers	Diver ID #	DCS	Comments
	Dives in set 1		32			
Dive Group 2. 120 fsw 50 min air dive with surface decompression with air						
Nov19	SURD201.LOG	120/50	3	4, 27, 35	0	
Nov19	SURD202.LOG	120/50	3	25, 33, 36	0	
Nov19	SURD203.LOG	120/50	3	1, 2, 20	0	
Dec04	SURD204.LOG	120/50	3	10, 14, 29	0	
Dec04	SURD205.LOG	120/50	3	1, 2, 3	0	
Dec06	SURD206.LOG	120/50	3	4, 5, 6	0	
Dec06	SURD207.LOG	120/50	3	7, 8, 9	0	
Dec11	SURD208.LOG	120/50	2	8, 10	0	
Dec11	SURD209.LOG	120/50	3	9, 11, 12	0	
Dec13	SURD210.LOG	120/50	3	2, 13, 14	0	
Dec13	SURD211.LOG	120/50	3	7, 15, 16	0	
	Dives in set 2		32			
Dive Group 3. 60 fsw air dive with surface decompression with oxygen						
Jul05	SURD301.LOG	60/180	3	10, 17, 18	0	
Jul06	SURD302.LOG	60/180	3	8, 9, 19	0	
Jul09	SURD303.LOG	60/180	3	15, 20, 21	0	
Jul10	SURD304.LOG	60/180	3	7, 22, 23	0	
Jul11	SURD305.LOG	60/180	3	12, 24, 25	0	
Jul12	SURD306.LOG	60/180	3	4, 6, 18	0	
	Dives in set 3		18			
Dive Group 4. 120 fsw air dive with surface decompression with oxygen						
Jul16	SURD401.LOG	120/50	3	11, 15, 25	0	
Jul17	SURD402.LOG	120/50	3	26, 27, 28	0	
Jul18	SURD403.LOG	120/50	3	8, 12, 21	0	
Jul19	SURD404.LOG	120/50	3	4, 20, 29	0	

Dive date	Dive ID #	Depth/ Time	# of divers	Diver ID #	DCS	Comments
Jul19	SURD405.LOG	120/50	3	17, 19, 23	0	
Jul24	SURD406.LOG	120/50	3	4, 7, 30	0	
Jul24	SURD407.LOG	120/50	3	6, 8, 10	0	
Jul26	SURD408.LOG	120/50	3	5, 11, 31	0	
Jul26	SURD409.LOG	120/50	3	12, 27, 28	1	DCS Type II, Diver 27
	Dives in set 4		27	DCS in set	1	
	Total dives		109	Total DCS	1	

For each of the groups the following data are enclosed:

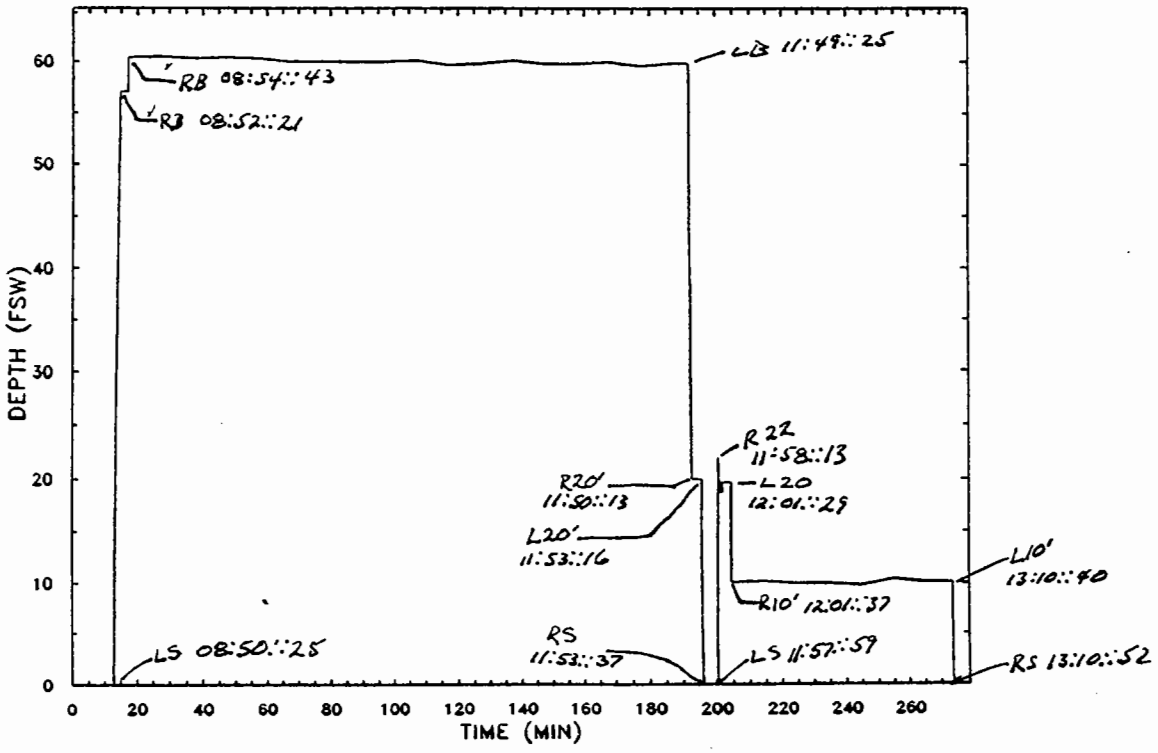
- Graphical profile of the dive
- Dive profile log extract
- Medical report (Group 4 only)

2. Group 1, 60 fsw/180 min with Sur-D/air, Dives SURD101 through SURD112

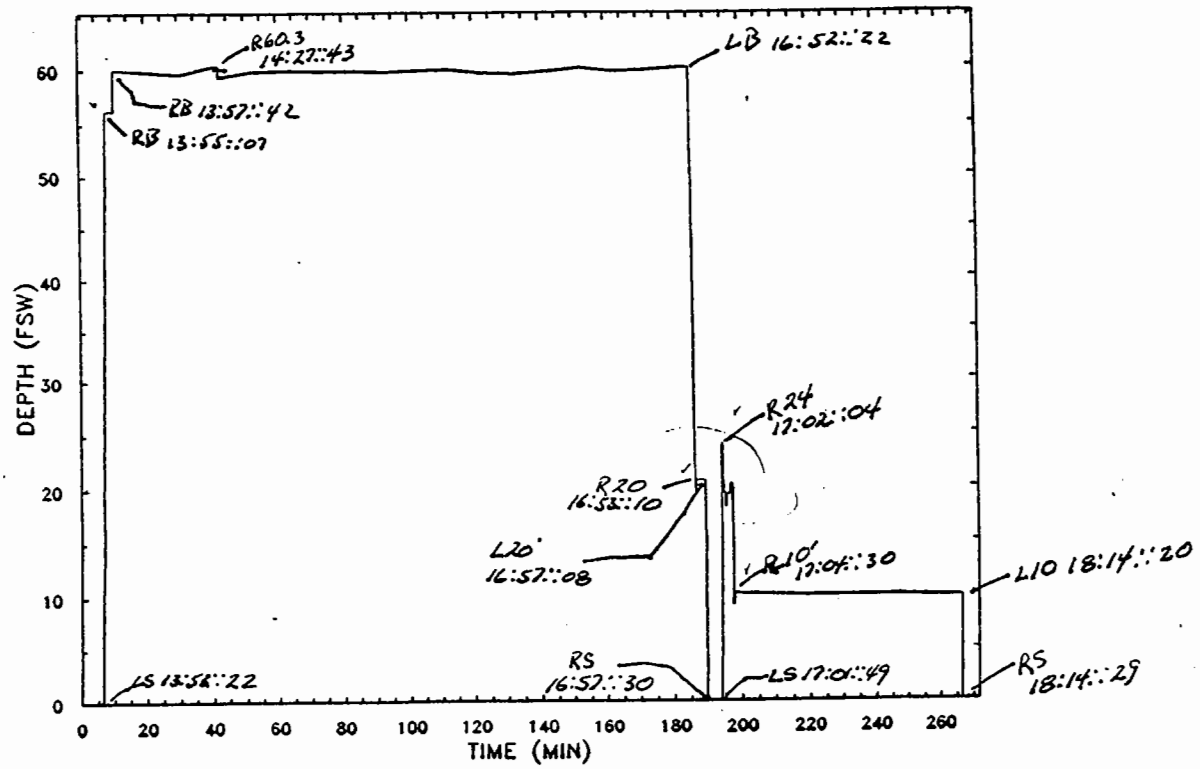
a. Graphic plots

The graphic profiles follow. Dive SURD106 was aborted due to sinus squeeze.

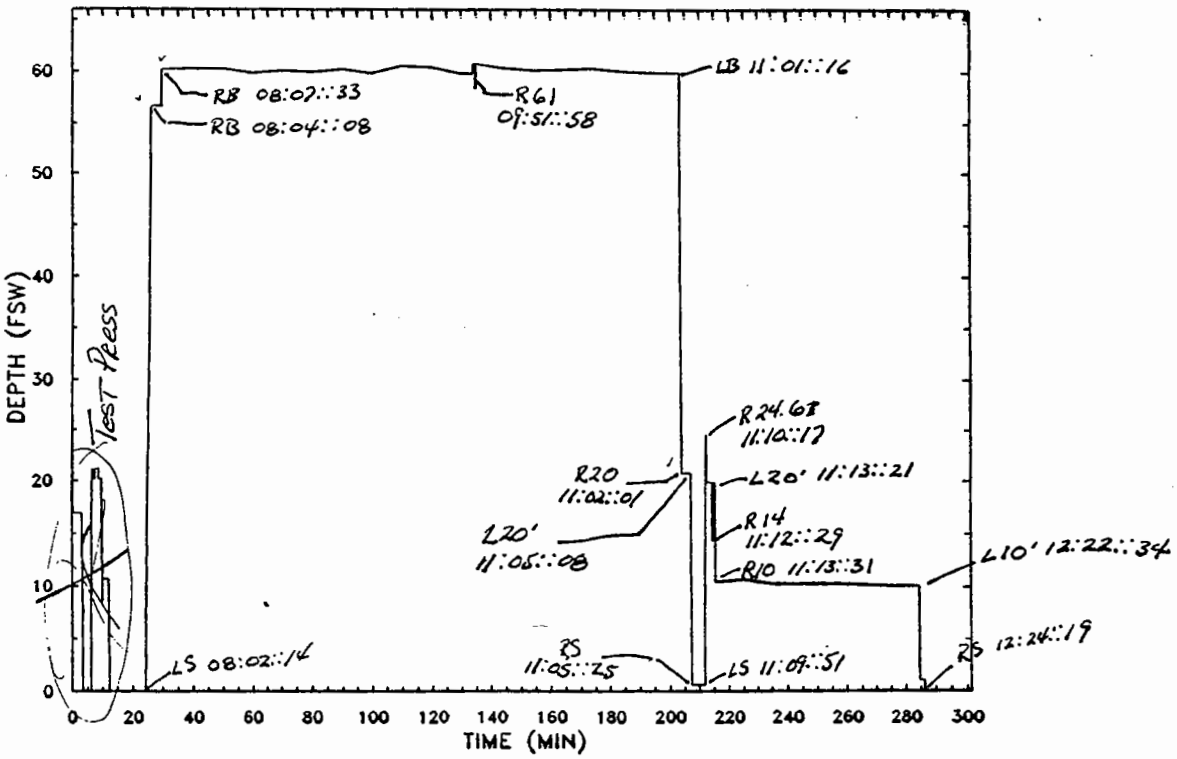
SURD101.LOG 06-NOV-90 2/19/20 3/0



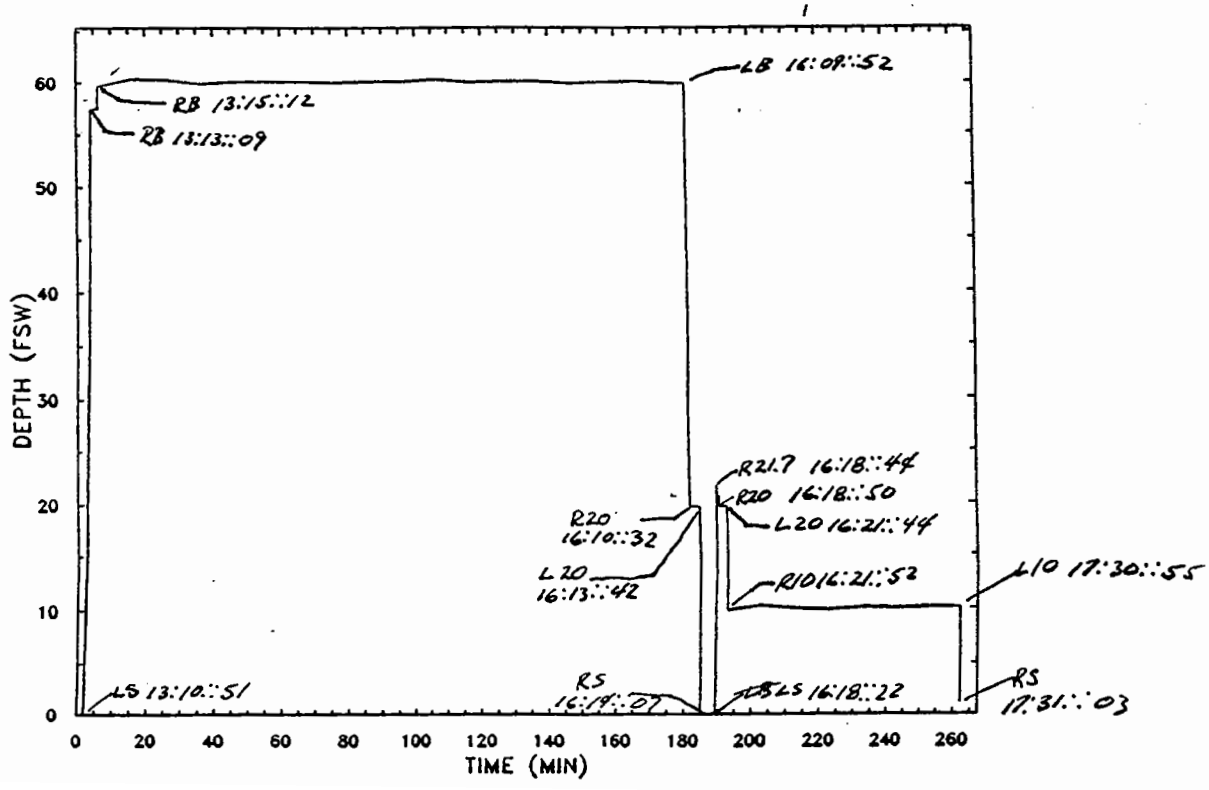
SURD102.LOG 06-NOV-90 3/0



SURD103.LOG 08-NOV-90 1, 8, 32 3/0

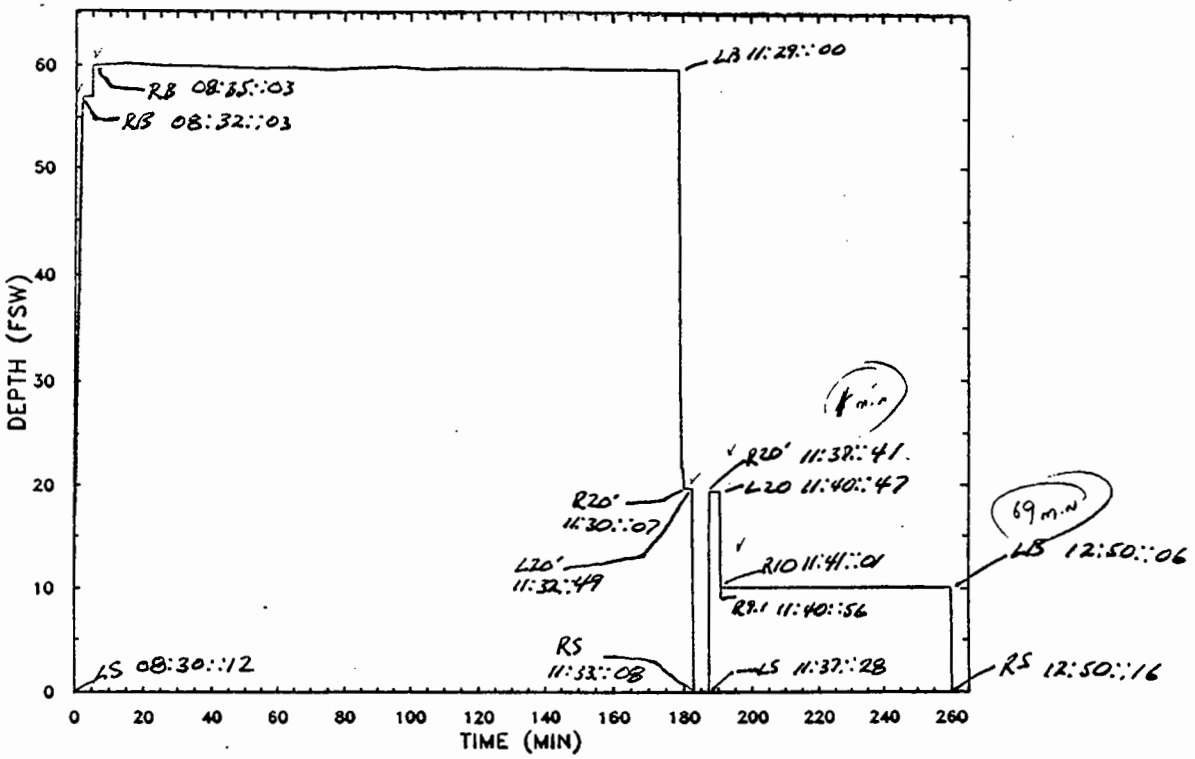


SURD104.LOG 08-NOV-90 3/0



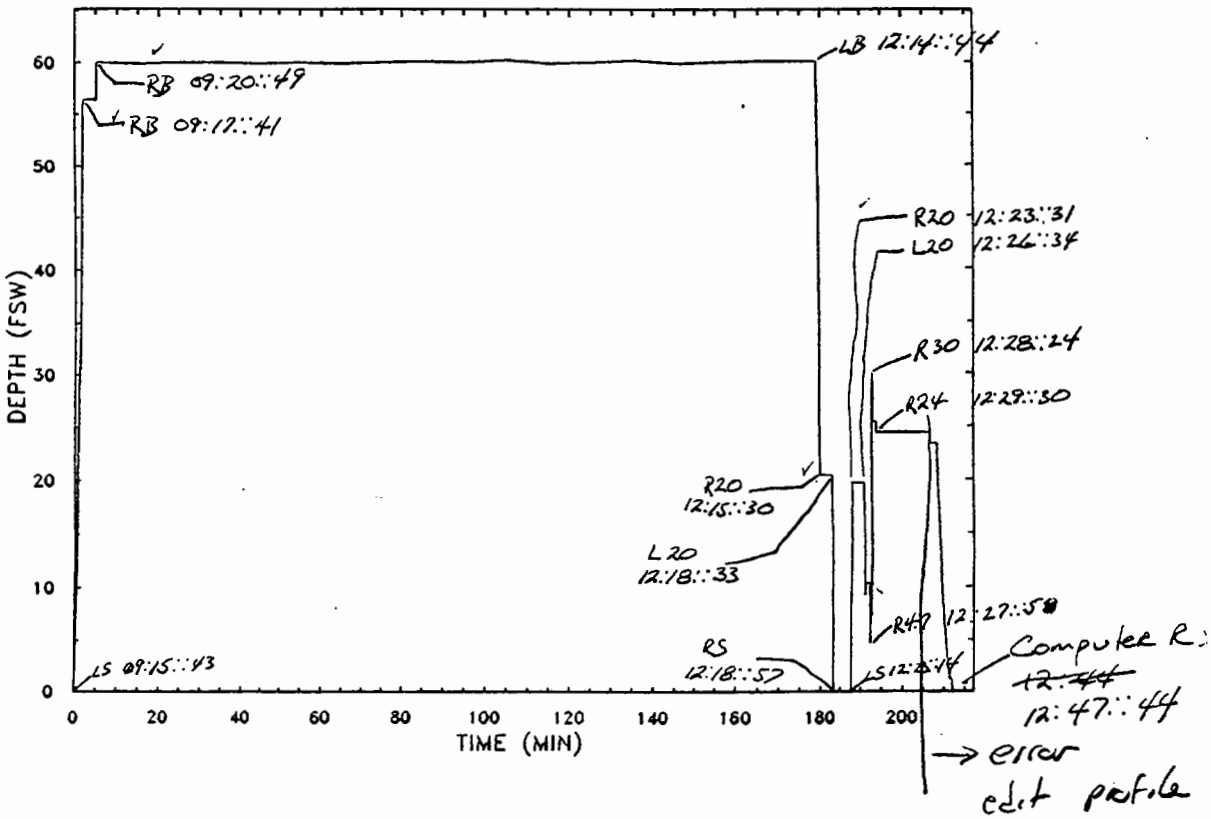
SURD105.LOG 13-NOV-90

5, 6, 12 3/0

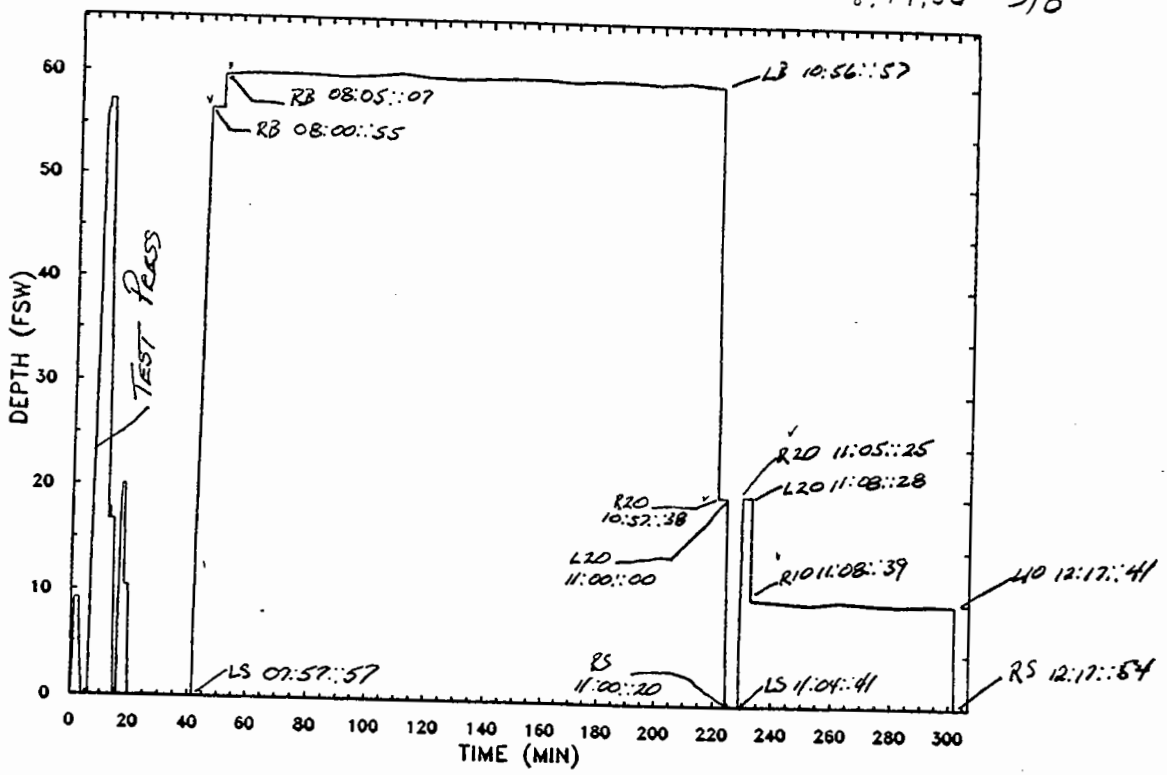


Air 16 26 27 ✓ 3/0

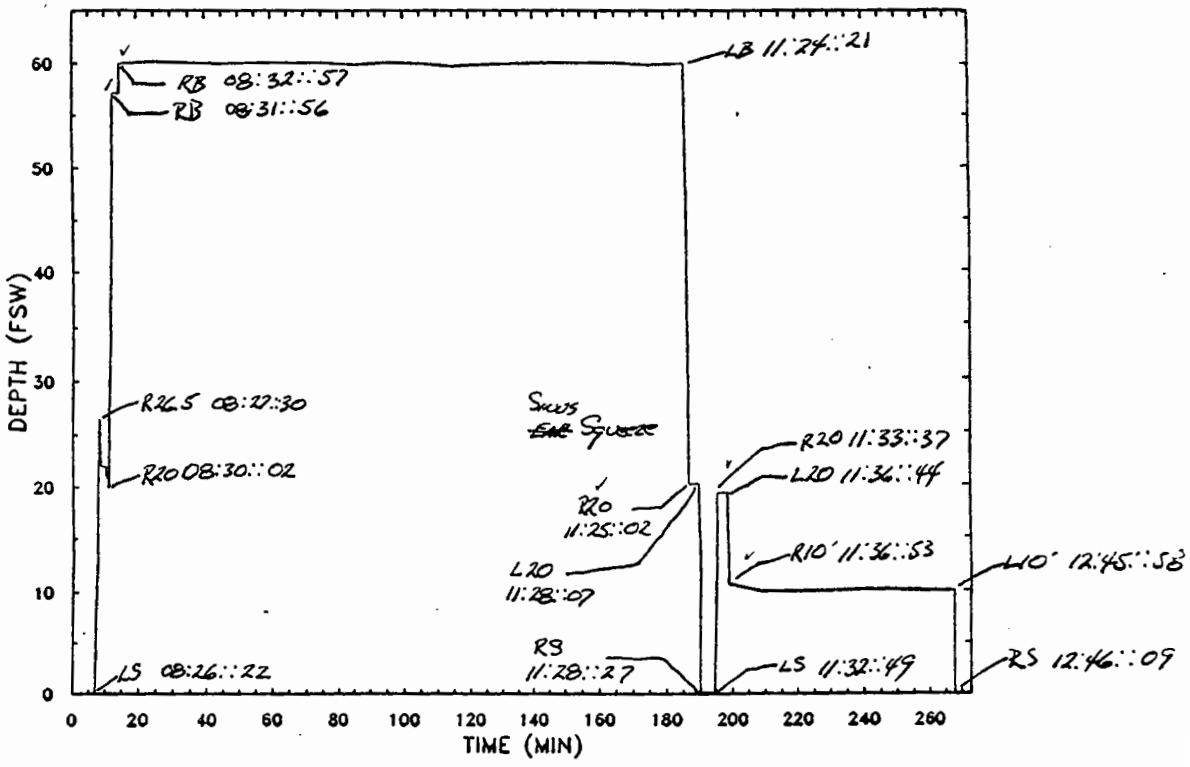
SURD107.LOG 15-NOV-90



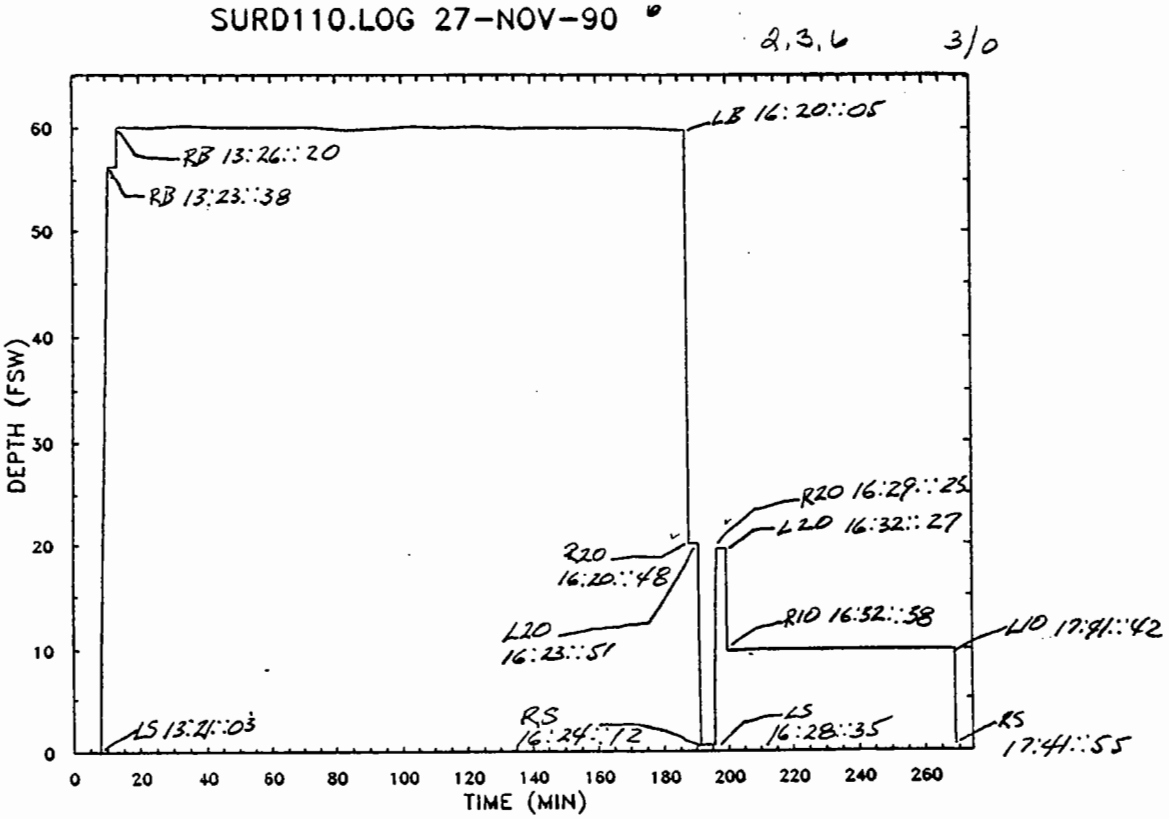
SURD108.LOG 16-NOV-90

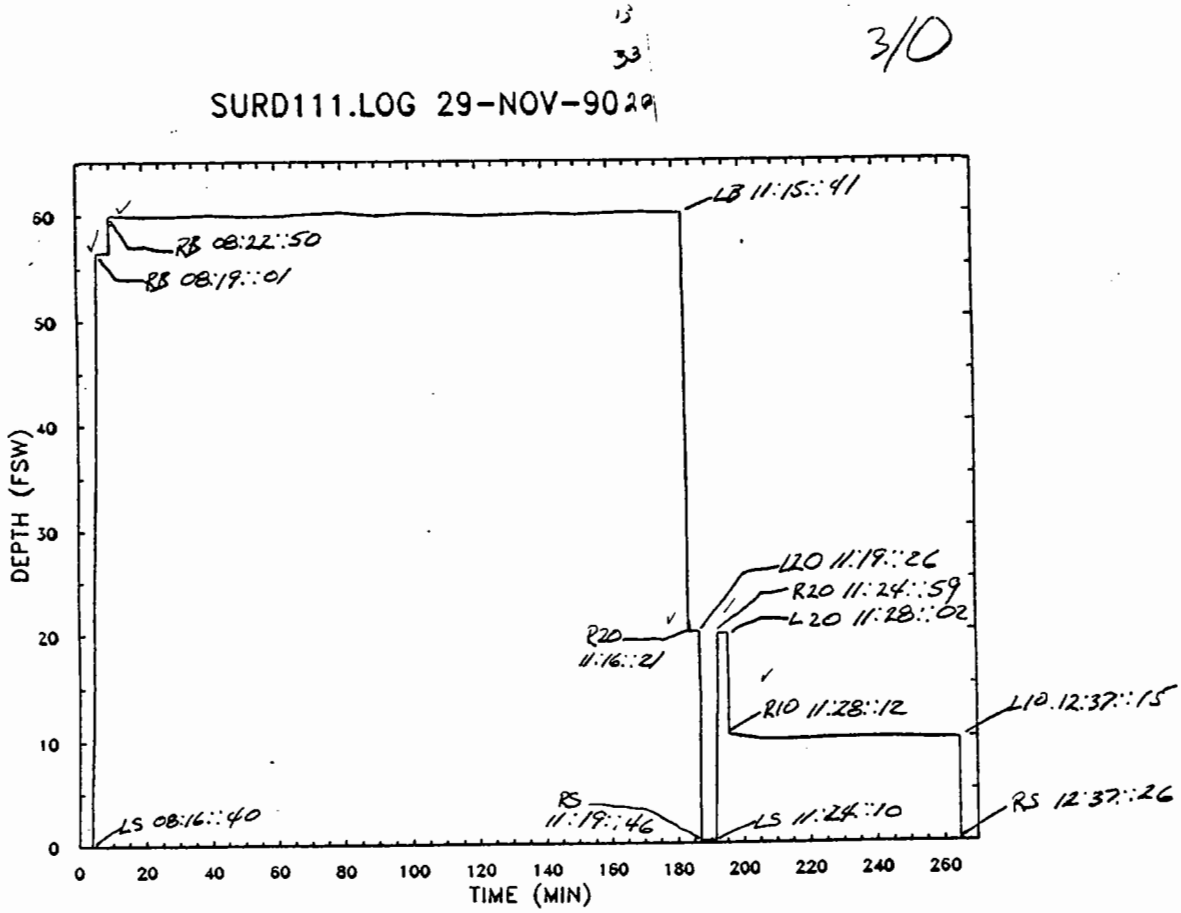


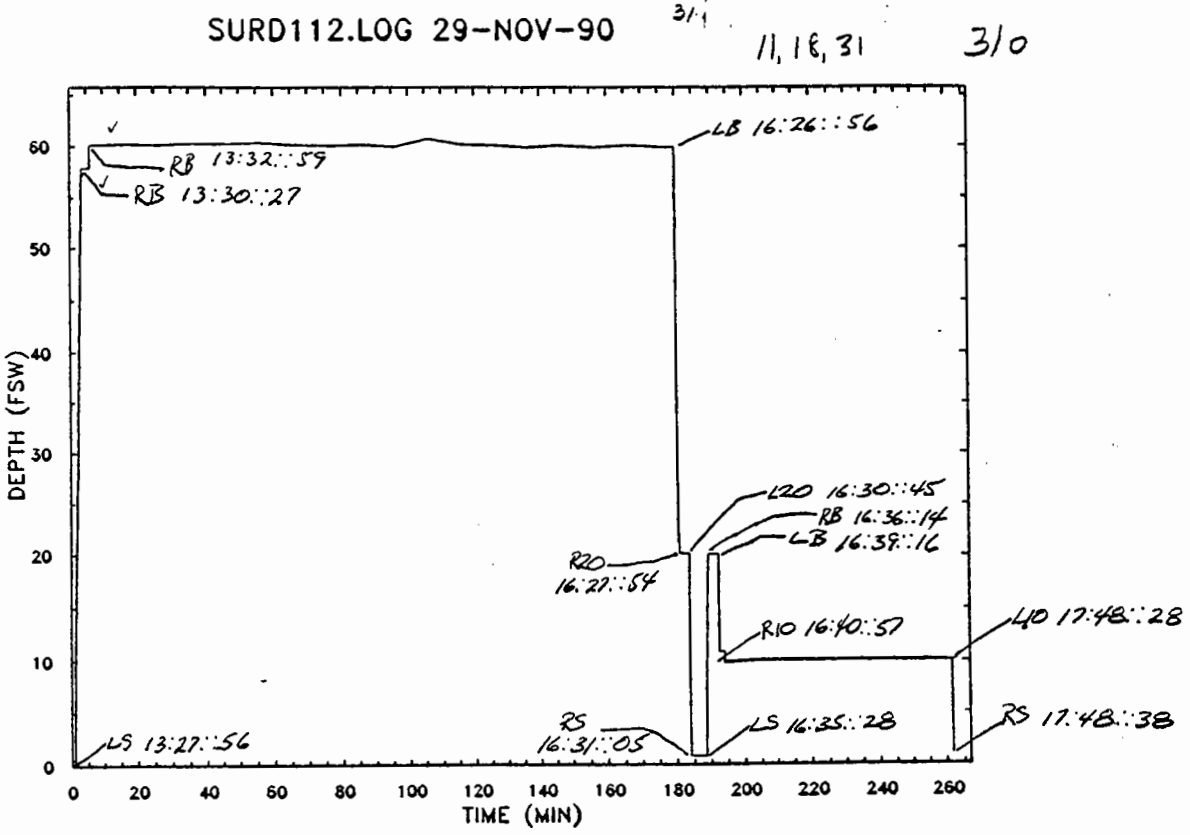
SURD109.LOG 27-NOV-90



Graphic plots, dives SURD101 through SURD112. 60 fsw/180 min, sur-d/air.






SURD112.LOG 29-NOV-90
11, 18, 31
3/0
DEPTH (FSW)
TIME (MIN)
LB 16:26::56
RB 13:32::59
RB 13:30::27
L20 16:30::45
RB 16:36::14
LB 16:39::16
R20 16:27::54
R10 16:40::57
L0 17:48::28
RS 16:31::05
LS 16:35::28
RS 17:48::38
LS 13:27::56

b. Dive profile extract

Because there profile plots of all the dives we considered it worthwhile to submit an extract of the computer log rather than include all pages. These are bulky and many contain essentially no useful information.

We have tried to show profile changes where the depth changed more than 0.1 fsw. Time is short for many of the small changes in pressure. For example, the time between reaching bottom in chamber pressure (the first RB) and reaching the second RB which was when the divers entered the water, was only a second or two. Since there is only a second or two difference between leaving one depth and reaching the next we have included only one of the points. The graphic log makes it easy to tell what has happened. That is, when the travel time is insignificant only the arrival time is shown.

Some times were pencilled in as corrections to the computer printout. These are indicated as "handwritten time." In some cases the computer still showed a pressure of, say. 0.1 fsw on arrival at surface. In these cases the computer value is given also.

In some cases data is included that may seem redundant or unnecessary; we tried to err on the side of more data.

In some cases the diver is on oxygen at the end and "off O_2" is not shown.

Entries such as clock time that are not complete are left as they are on the log.

These notes apply to all log extracts.

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, Sur-D/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
2, 14, 20	90NOV06	SURD101	08:50::25	12.809	LS	0.0	
			08:52::21	14.741	RB	57.0	
			08:54::43	17.125	RB	60.4	
				27.137	+10	60.5	
				37.143	+20	60.3	
				47.154	+30	60.4	
				57.162	+40	60.3	
				67.168	+50	60.0	
				77.174	+60	60.0	
				87.182	+70	60.0	
				97.195	+80	60.0	
				107.204	+90	60.1	
				117.211	+100	59.7	
				127.219	+110	59.8	
				137.226	+120	60.1	
				147.232	+130	59.8	
				157.239	+140	59.8	
				167.251	+150	60.0	
				177.259	+160	59.6	
				187.266	+170	59.9	
			11:49::25	191.827	LB	59.9	
			11:50::13	192.632	R20	20.0	
			11:53::16	195.683	L20	20.0	
			11:53::37	196.042	RS	0.0	
			11:57::59	200,409	LS	0.0	
			11:58::11	200.622	R20	19.0	Handwrittentime
				200.636		20.8	
			11:58::13	200.665	R22	22.0	
				200.760		22.0	
				200.782		20.9	
				200.838		19.9	
				201.133		19.9	
				201.156		18.7	
				201.739		18.7	
				201.762		19.7	
				204..413		19.7	
			12:01::37	204.556	R10	10.1	
				214.563	+10	10.2	
				224.569	+20	10.0	
				234.577	+30	10.0	
				244.589	+40	9.8	
				254.596	+50	10.4	
				264.603	+60	10.1	
			13:10::40	273.610	L10	10.1	
			13:10::52	273.808	RS	0.0	
17, 27, 31	90NOV06	SURD102	13:53::22	6.374	LS	0.0	

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			13:55::07	8.130	RB	56.3	
			13:57::42	10.714	RB	60.0	
				20.726	+10	59.8	
				30.733	+20	59.6	
			14:22::43	40.740	+30	60.3	
				42.524		60.3	
			14:27::43	42.546		59.3	
				52.554	+42	59.8	
				62.560	+52	56.9	
				72.572	+62	59.8	
				82.578	+72	59.8	
				92.585	+82	59.7	
				102.592	+92	59.8	
				112.598	+102	59.9	
				122.605	+112	59.6	
				132.611	+122	59.5	
				142.622	+132	59.7	
				152.629	+142	60.0	
				162.636	+152	59.7	
				172.642	+162	59.8	
				182.649	+172	60.0	
			16:52::22	185.391	LB	60.0	
			16:53::10	186.191	R20	19.7	
			16:57::08	189.161	L20	20.7	
			16:57::30	189.540	RS	0.0	
			17:01::49	193.862	LS	0.0	
			17:02::04	194.118	R24	24.0	
				194.264		24.0	
				194.286		22.8	
				194.358		21.5	
			17:02::22	194.430		20.05	
				194.546		20.5	
				194.569		19.5	
				195.153		19.5	
			17:04::30	197.297	R10	10.5	
				197.325		9.2	
				197.487		9.2	
				197.509		10.2	
				207.521	+10	10.1	
				217.528	+20	10.0	
				227.535	+30	10.0	
				237.542	+40	10.0	
				247.548	+50	10.0	
				257.555	+60	9.9	
			18:14::20	266.407	L10	9.9	
			18:14::29	266.547	RS	0.0	
1, 8, 32	90NOV08	SURD103	08:02::14	24.242	LS	0.0	
			08:04::08	26.149	RB	56.7	

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			08:07::33	29.576	RB	60.2	
				39.589	+10	60.3	
				49.599	+20	60.3	
				59.606	+30	59.9	
				69.614	+40	60.1	
				79.624	+50	60.0	
				89.630	+60	60.3	
				99.642	+70	59.9	
				109.649	+80	60.6	
				119.656	+90	60.5	
				129.663	+100	59.9	
				133.981	+104	59.9	
			09:51::58	134.003	R61	60.9	Pressure deviation
				144.010	+115	60.4	
				154.023	+125	60.2	
				164.030	+135	60.3	
				174.036	+145	60.4	
				184.044	+155	60.1	
				194.050	+165	60.0	
			11:01::16	203.278	LB	60.0	
			11:02::01	204.042	R20	20.8	
			11:05::08	207.170	L20	20.8	Handwritten time
			11:05::25	207.465	RS	0.0	Computer says 1.7
			11:09::51	211.903	LS	0.0	Computer says 0.6
			11:10::17	212.331	R24	24.6	
				212.426		24.6	
				212.448		23.3	
				212.499		22.1	
				212.555		21.0	
				212.628		19.9	
				214.456		19.9	
				214.478		18.8	
				214.507		17.1	
				214.536		14.4	
			11:12::29	214.721	R14.4	14.4	
				214.743		15.5	
				214.778		16.5	
				214.828		18.3	
				214.879		19.9	
			11:13::21	215.406	LB	19.9	Handwritten time
			11:13::31	215.534	R10	10.5	
				225.541	+10	10.7	
				235.547	+20	10.3	
				245.553	+30	10.3	
				255.560	+40	10.3	
				265.573	+50	10.2	
				275.580	+60	10.1	
				284.598	L10	10.1	Handwritten time
			12:24::19	286.313	RS	0.0	

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
3, 11, 24	90Nov08	SURD104	13:10::51	1.844	LS	0.0	
			13:13::09	4.157	RB	56.2	Handwritten time
				4.194		57.4	
				6.201		57.4	
			13:15::12	6.223	RB	59.7	
				16.229	+10	60.4	
				26.241	+20	60.3	
				36.246	+30	59.9	
				46.252	+40	60.1	
				56.258	+50	60.1	
				66.266	+60	60.1	
				76.273	+70	60.0	
				86.280	+80	60.1	
				96.294	+90	60.1	
				106.300	+100	60.3	
				116.306	+110	60.0	
				126.312	+120	60.1	
				136.321	+130	60.1	
				146.328	+140	59.9	
				156.336	+150	60.0	
				166.347	+160	60.1	
				176.355	+170	59.9	
			16:09::52	180.874	LB	59.9	
			16:10::32	181.555	R20	24.2	Handwritten time
				181.570		22.8	
				181.620		21.0	
				181.675		19.7	
			16:13::42	184.726	L20	19.7	
			16:14::07	185.147	RS	0.0	
			16:18::22	189.398	LS	0.0	
			16:18::44	189.767	R21.7	21.7	
			16:18::50	189.883	R20	20.7	
				190.405		20.7	
				190.427		19.7	
				192.789		19.7	
			16:21::52	192.931	R10	9.9	
				202.938	+10	10.3	
				212.944	+20	10.0	
				222.953	+30	9.9	
				232.959	+40	10.1	
				242.966	+50	10.0	
				252.978	+60	10.1	
			17:30::50	261.985	L10	10.1	
			17:31::03	262.120	RS	0.0	Computer says 1.1
5, 6, 12	90NOV13	SURD105	08:30::12	0.000	LS	0.0	Computer says 10.6
			08:32::03	1.855	RB	57.0	Data points added
			08:35::03	4.861	RB	60.0	to data base

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				14.870	+10	60.2	
				24.877	+20	60.0	
				34.885	+30	60.0	
				44.893	+40	59.9	
				54.905	+50	59.8	
				64.914	+60	59.9	
				74.921	+70	59.7	
				84.928	+80	59.9	
				94.934	+90	60.0	
				104.943	+100	59.7	
				114.950	+110	59.9	
				124.963	+120	59.9	
				134.971	+130	59.8	
				144.979	+140	59.9	
				154.988	+150	59.8	
				164.994	+160	59.8	
				175.001	+166	59.8	
			11:29::00	178.797	LB	59.8	Handwritten time
			11:30::07	179.917	R20	20.7	
				180.240		20.7	
				180.262		19.7	
			11:32::49	182.625	L20	19.7	
			11:33::08	182.953	RS	0.0	Handwritten time
			11:37::28	187.301	LS	0.0	
			11:37::41	187.530	R20	19.4	
			11:40::47	190.624	L20	19.4	
			11:40::56	190.794	R9	9.1	
			11:41::01	190.889	R10	10.1	
			12:50::06	259.968	L10	10.1	
			12:50::16	260.139	RS	0.0	
	90NOV13	SURD106			Dive aborted due to tender sinus block.		
10, 26, 27	90NOV15	SURD107	09:15::43	0.000	LS	0.0	
			09:17::41	1.972	RB	56.4	
			09:20::49	5.116	RB	60.0	
				15.124	+10	59.9	
				25.131	+20	60.0	
				35.139	+30	60.0	
				45.147	+40	59.9	
				55.154	+50	60.0	
				65.166	+60	59.9	
				75.172	+70	60.0	
				85.181	+80	60.1	
				95.191	+90	60.0	
				105.200	+100	60.2	
				115.209	+110	59.9	
				125.218	+120	60.0	
				135.232	+130	60.2	

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				145.241	+140	59.9	
				155.248	+150	60.0	
				165.255	+160	60.1	
				175.262	+170	60.1	
			12:14::44	179.046	LB	60.1	
			12:15::30	179.816	R20	20.4	
			12:18::33	182.878	L20	20.4	Handwritten time
			12:18::57	183.278	RS	0.0	
			12:23::14	187.573	LS	0.0	
			12:23::31	187.859	R20	19.7	
			12:26::34	190.914	L20	17.6	
			12:26::40	191.028	R10	10.4	
				192.254	L10	10.3	
			12:27::58	192.333	R4.7	4.7	
				192.688	R7.3	7.3	
			12:28::24	192.767	R30	30.0	Rate 287 fpm for 0.08s
				192.817		28.9	
			12:29::30	193.870	R24	24.4	
			12:42::20	206.707	L24	24.4	
				208.490		22.7	
				208.512		23.3	
				210.094		23.3	
				210.323		19.6	
				211.037		19.1	
			12:46	210.323		19.6	Handwritten log
			12:47::44				Computer RS
			12:58	222.		20.0	Handwritten log
			12:58::10	222.5		10.0	Handwritten log
			14:07	231.5	L10	10.0	Handwritten log
			14:08	232.5	RS	0.0	Handwritten log
8, 14, 33	90NOV16	SURD108	07:57::57	41.400	LS	0.0	
			08:00::55	44.376	RB	56.6	
			08:05::07	48.581	RB	59.8	
				58.596	+10	60.0	
				68.603	+20	60.0	
				78.610	+30	60.0	
				88.618	+40	59.9	
				98.625	+50	60.0	
				108.633	+60	60.3	
				118.641	+70	60.0	
				128.655	+80	59.9	
				138.663	+90	60.0	
				148.671	+100	60.1	
				158.679	+110	60.1	
				168.686	+120	59.9	
				178.693	+130	60.1	
				188.701	+140	60.1	
				198.708	+150	59.9	

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				208.719	+160	60.1	
				218.728	+170	59.8	
			10:56::57	220.426	LB	59.8	
			10:57::38	221.116	R20	21.2	Handwritten time
				221.131		19.9	
				224.116	L20	19.9	
			11:00::20	224.485	RS	0.0	
			11:04::41	228.846	LS	0.0	
			11:05::25	229.587	R20	20.0	
			11:08::39	232.829	R10	10.2	
				242.836	+10	10.0	
				252.849	+20	9.8	
				262.858	+30	10.1	
				272.865	+40	9.9	
				282.872	+50	9.8	
				292.879	+60	9.9	
			12:17::41	301.864	L10	9.9	
			12:17::54	302.084	RS	0.0	
10, 15, 17	90NOC27	SURD109	08:26::22	7.013	LS	0.0	
			08:27::30	8.160	R26.5	26.5	#17, Ear squeeze, OK
				8.426		26.5	
			08:27::58	8.631	R22	22.0	
			08:30::02	10.710	R20	20.0	
			08:30::26	11.116	L20	20.0	
			08:31::56	12.625	RB	57.1	
			08:32::57	14.654	RB	60.0	
				24.662	+10	60.2	
				34.669	+20	60.1	
				44.677	+30	60.0	
				54.684	+40	60.1	
				64.696	+50	60.1	
				74.704	+60	60.1	
				84.711	+70	59.9	
				94.718	+80	60.1	
				104.724	+90	60.0	
				114.733	+100	59.7	
				124.741	+110	59.9	
				134.753	+120	60.0	
				144.760	+130	60.1	
				154.770	+140	60.1	
				164.778	+150	60.1	
				174.786	+160	59.9	
				184.793	+170	60.0	
			11:24::21	186.066	LB	60.0	
			11:25::02	186.753	R20	20.2	
			11:28::07	189.848	L20	20.2	
			11:28::27	190.188	RS	0.0	Computer says 0.1
			11:32::49	194.571	LS	0.0	Computer says 0.1

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			11:33::37	195.364	R20	19.3	
			11:36::53	198.622	R10	10.7	
				208.629	+10	10.0	
				218.636	+20	10.0	
				228.644	+30	10.0	
				238.650	+40	10.1	
				248.663	+50	10.1	
				258.672	+60	10.0	
			12:45::58	267.703	L10	10.0	
			12:46::09	267.895	RS	0.0	Computer says 0.1
2, 3, 6	90NOV27	SURD110	13:21::03	8.051	LS	0.0	
			13:23::38	10.639	RB	56.3	
			13:26::20	13.334	RB	60.1	
				23.342	+10	60.0	
				33.351	+20	60.2	
				43.358	+30	60.1	
				53.366	+40	60.1	
				63.380	+50	60.1	
				73.387	+60	60.1	
				83.395	+70	59.8	
				93.405	+80	60.0	
				103.412	+90	60.2	
				113.419	+100	60.1	
				123.428	+110	60.2	
				133.439	+120	60.0	
				143.448	+130	60.1	
				153.456	+140	60.1	
				163.464	+150	60.1	
				173.473	+160	60.1	
				183.479	+170	59.9	
			16:20::05	187.089	LB	59.9	
			16:20::48	187.816	R20	20.1	
			16:23::51	190.867	L20	20.1	
			16:24::12	191.219	RS	0.0	Computer says 0.6
			16:28::35	195.602	LS	0.0	Computer says 0.6
			16:20::48	187.816	R20	20.1	
			16:29::23	196.402	RB	19.6	
			16:32::38	199.668	R10	9.9	
			17:41::55	268.972	RS	0.6	Computer says 0.6
13, 20, 33	90NOV29	SURD111	08:16::40	3.717	LS	0.0	
			08:19::01	6.067	RB	56.5	
			08:22::50	9.897	RB	60.0	
				19.906	+10	59.9	
				29.921	+20	59.9	
				39.928	+30	60.0	
				49.937	+40	59.9	
				59.945	+50	59.9	

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				69.953	+60	60.1	
				79. 962	+70	60.2	
				89.972	+80	59.9	
				99.986	+90	60.1	
				109.995	+100	60.0	
				120.002	+111	59.8	
				130.011	+121	59.9	
				140.018	+131	60.0	
				150.024	141	59.9	
				160.034	+161	60.0	
				170.047	+171	60.1	
				180.056	+181	60.0	
			11:15::41	182.753	LB	60.0	
			11:16::21	183.419	R20	20.0	
				183.558		20.0	
				183.580		21.0	
				183.747		21.0	
				183.770		20.0	
			11:19::26	186.510	L20	20.0	
			11:19::46	186.849	RS	0.0	Computer says 0.2
			11:24::10	191.259	LS	0.0	Computer says 0.2
			11:24::59	192.081	R20	19.8	
			11:28::12	195.301	R10	10.4	
				205.307	+10	9.9	
				215.315	+20	9.9	
				225.323	+30	10.0	
				235.331	+40	10.0	
				245.345	+50	10.0	
				255.353	+60	9.9	
			12:37::15	264.360	L10	9.9	
			12:37::26	264.556	RS	0.0	
11, 18, 31	90NOV29	SURD112	13:27::56	0.949	LS	0.0	
			13:30::27	3.479	RB	56.7	
				3.532		57.9	
				6.006		57.9	
			13:32::59	6.028	RB	60.1	
				16.035	+10	60.2	
				26.042	+20	60.1	
				36.050	+30	60.3	
				46.062	+40	60.3	
				56.069	+50	60.4	
				66.078	+60	60.2	
				76.085	+70	60.1	
				86.093	+80	60.2	
				96.102	+90	60.0	
				106.110	+100	60.8	
				116.124	+110	60.2	
				126.130	+120	60.1	

Dive profile extract, Dives SURD101 through SURD112, 60 fsw/180 min, sur-d/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				136.138	+130	59.9	
				146.146	+140	60.1	
				156.153	+150	59.9	
				166.161	+160	60.1	
				176.167	+170	59.9	
			16:26::56	179.981	LB	59.9	
			16:27::54	180.964	R20	20.2	
			16:31::05	184.159	RS	0.0	Computer says 0.8
			16:35::28	188.542	LS	0.0	Computer says 0.8
			16:36::14	189.315	R20	20.1	
			16:39::16	192.344	L20	20.1	
			16:40::57	194.034	R10	9.9	
				204.047	+10	10.1	
				214.055	+20	10.1	
				224.063	+30	10.1	
				234.072	+40	10.1	
				244.080	+50	10.1	
				254.087	+60	10.1	
			17:48::28	261.562	LB	10.1	
			17:48::38	261.727	RS	0.0	Computer says 1.0

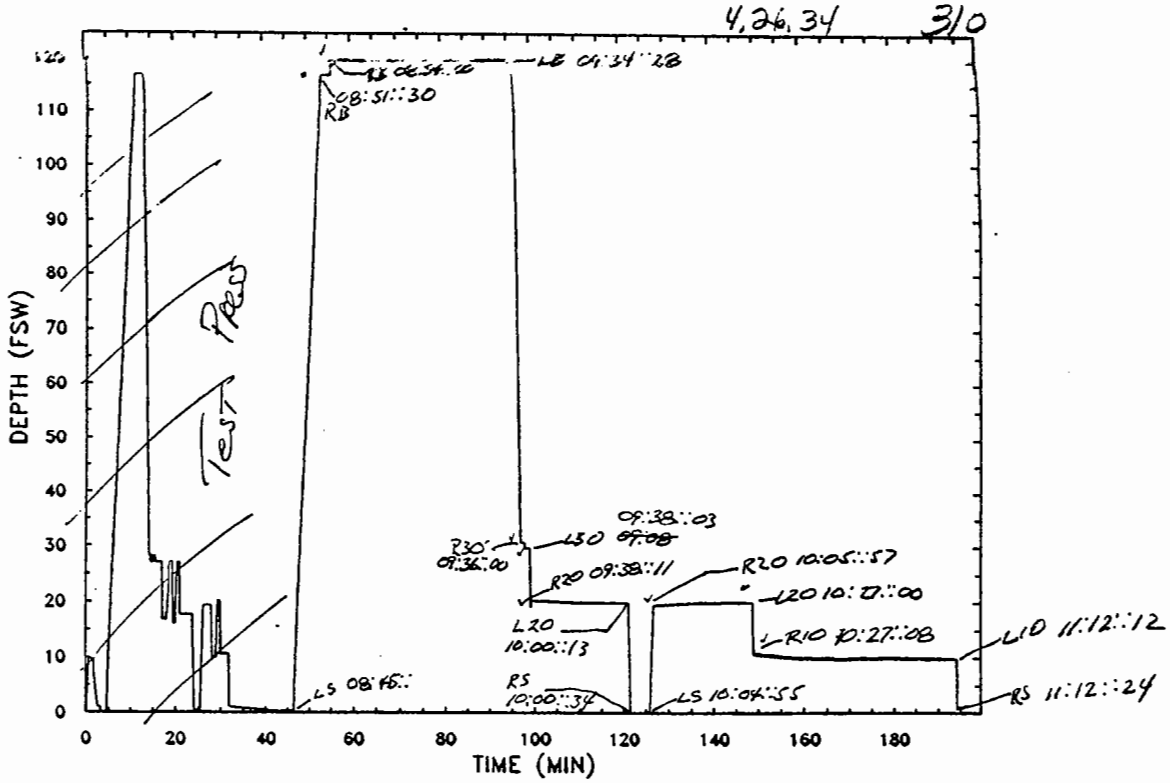
There are no medical reports for this group.

3. Group 2, 120 fsw/50min with Sur-D/air, Dives SURD201 through SURD211.

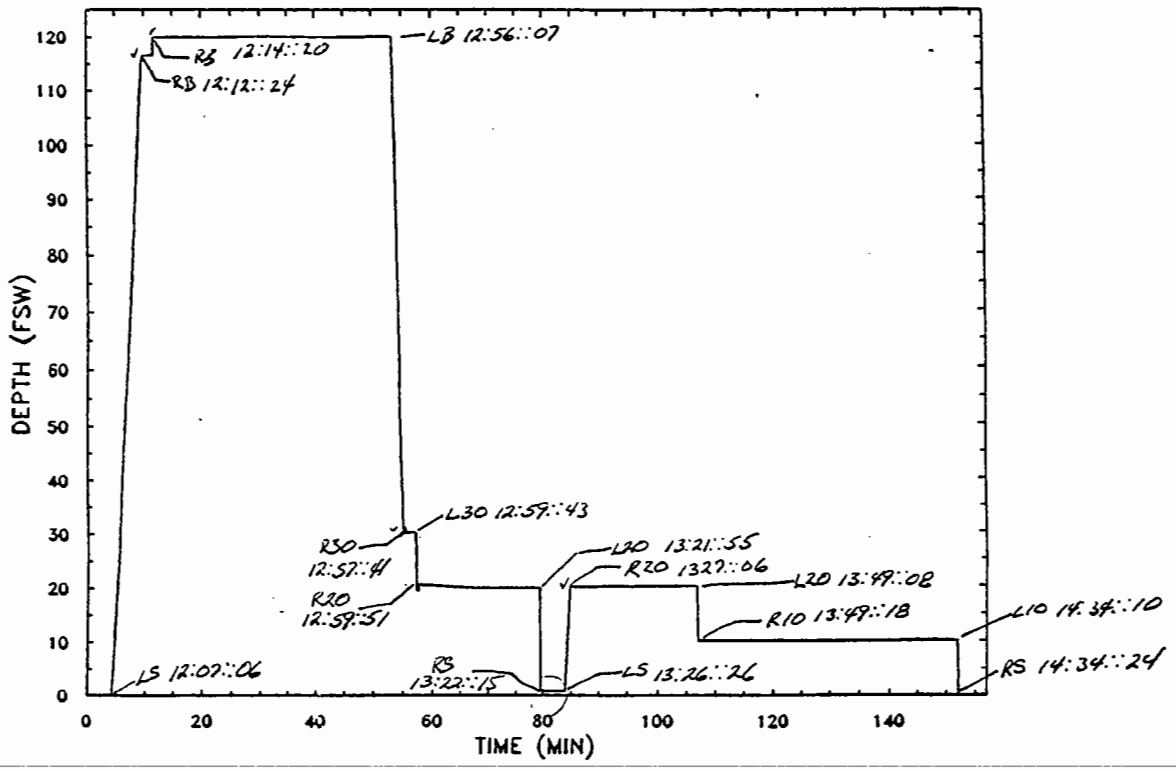
a. Graphic plots

The graphic profiles follow.

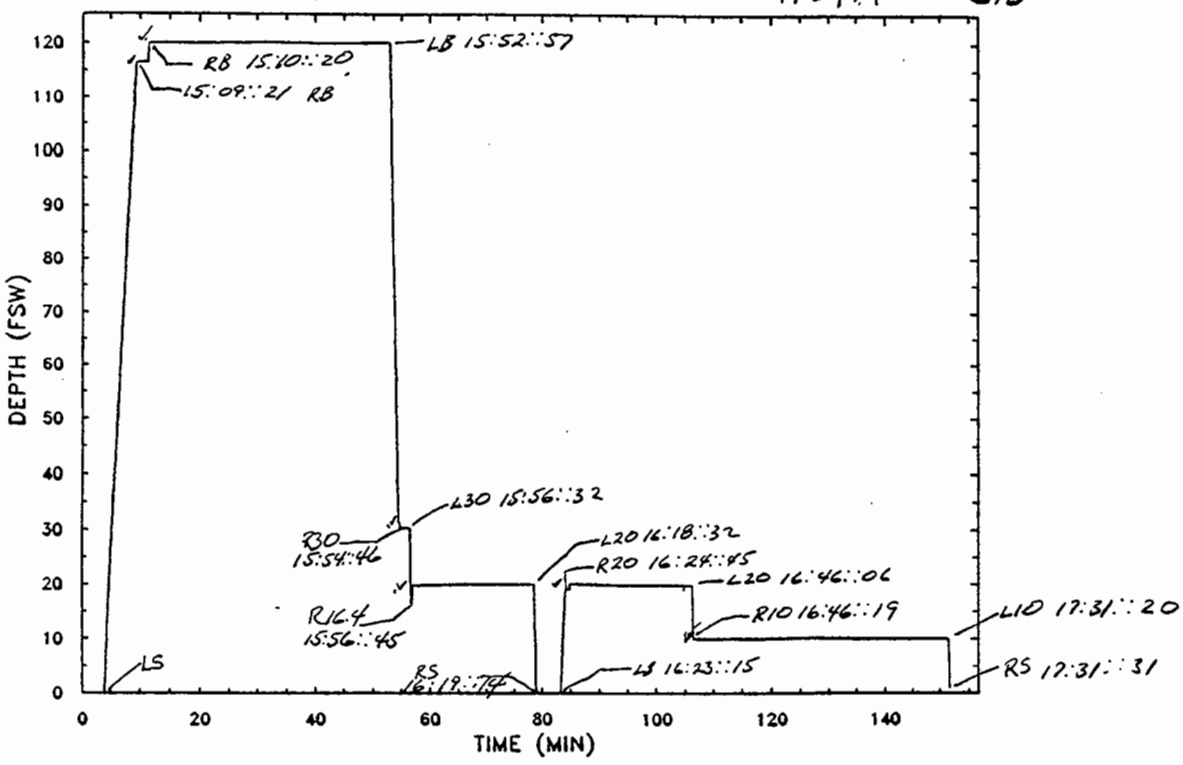
SURD201.LOG 19-NOV-90



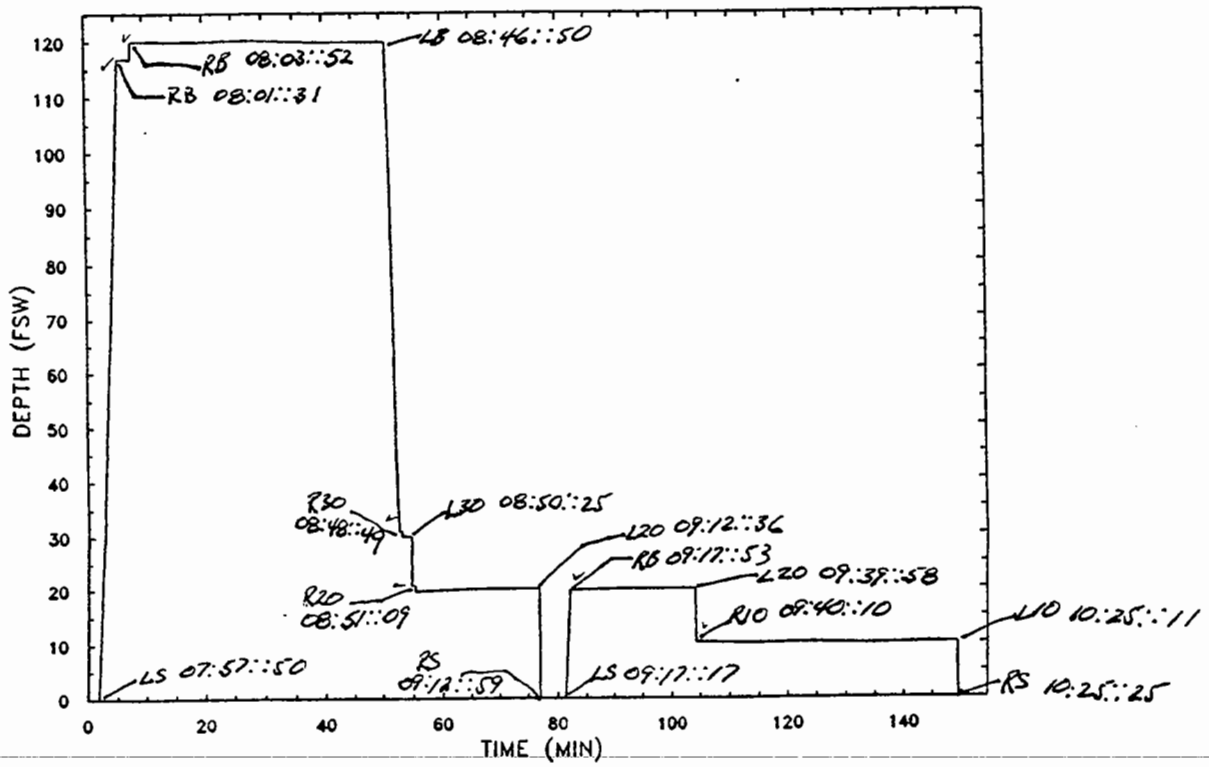
SURD202.LOG 19-NOV-90

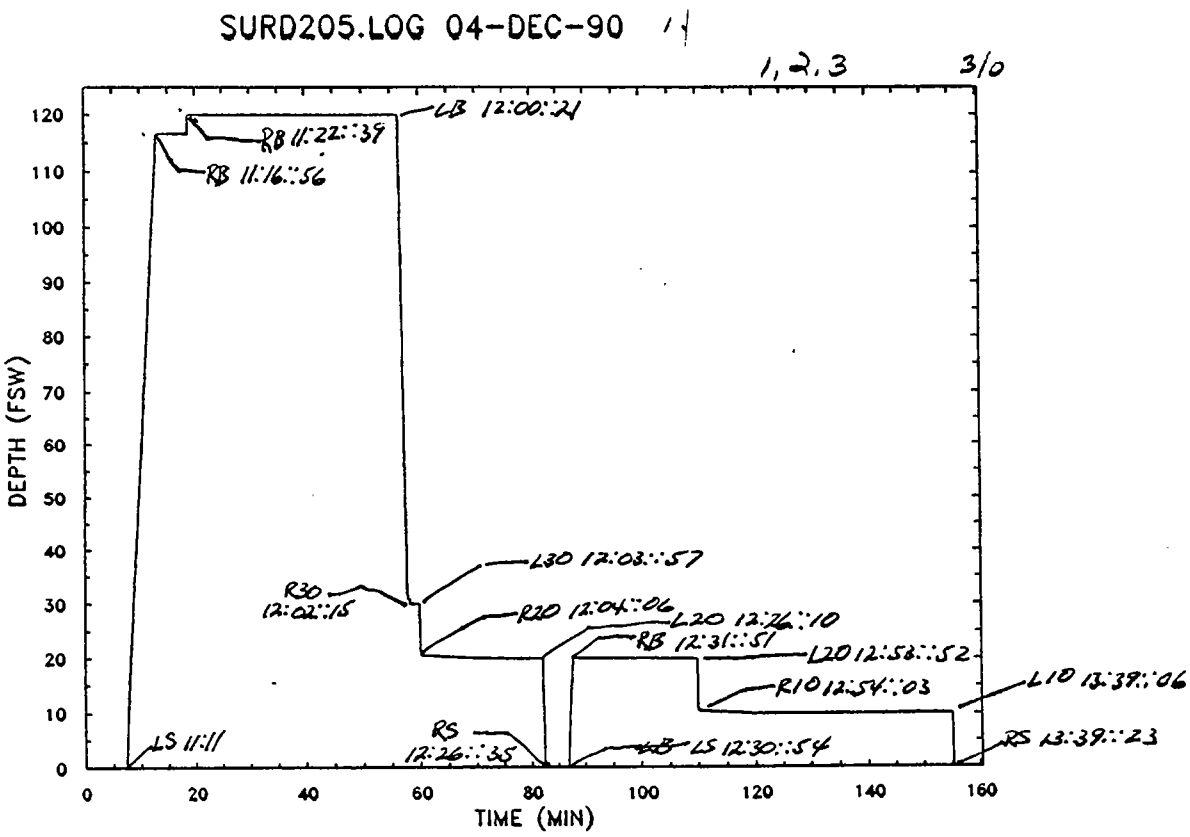


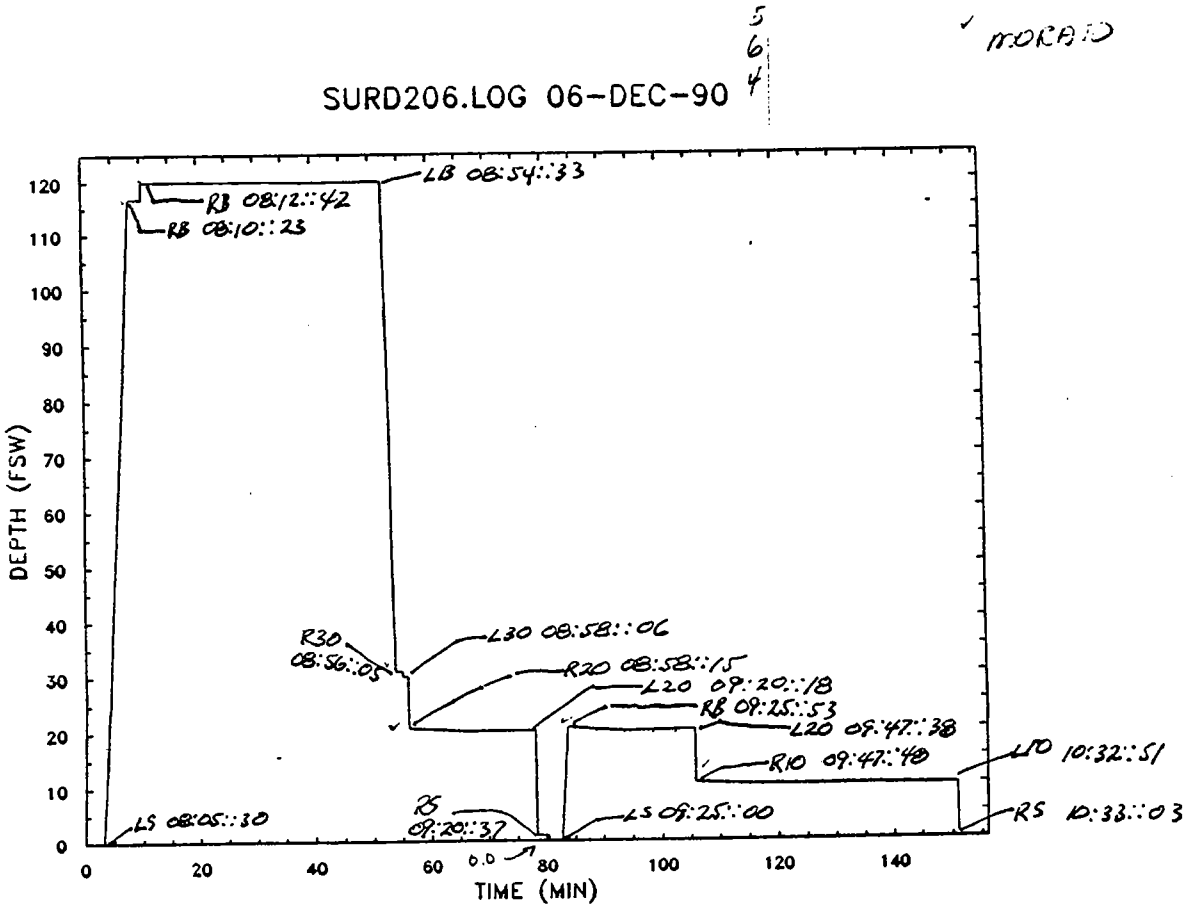
SURD203.LOG 19-NOV-90



SURD204.LOG 04-DEC-90

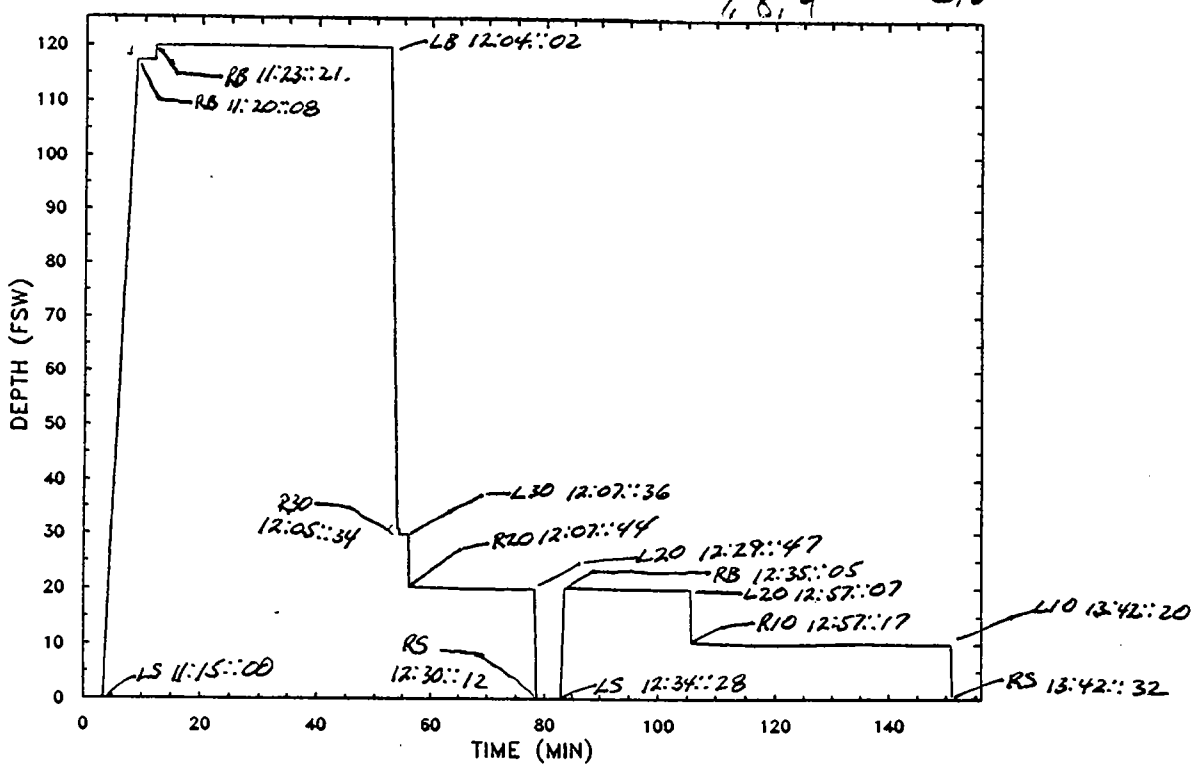



SURD205.LOG 04-DEC-90
1, 2, 3
3/0
DEPTH (FSW)
TIME (MIN)
LB 12:00::21
RB 11:22::39
RB 11:16::56
L30 12:03::57
R30 12:02::15
R20 12:04::06
L20 12:26::10
RB 12:31::51
L20 12:58::52
R10 12:54::03
L10 13:39::06
LS 11:11
RS 12:26::35
LS 12:30::54
RS 13:39::23


SURD206.LOG 06-DEC-90
5
6
4
MORAD
DEPTH (FSW)
TIME (MIN)
LB 08:54::33
RB 08:12::42
RB 08:10::23
L30 08:58::06
R30 08:56::05
R20 08:58::15
L20 09:20::18
RB 09:25::53
L20 09:47::38
R10 09:47::48
L10 10:32::51
LS 08:05::30
RS 09:20::37
LS 09:25::00
RS 10:33::03
0.0

SURD207.LOG 06-DEC-90 7

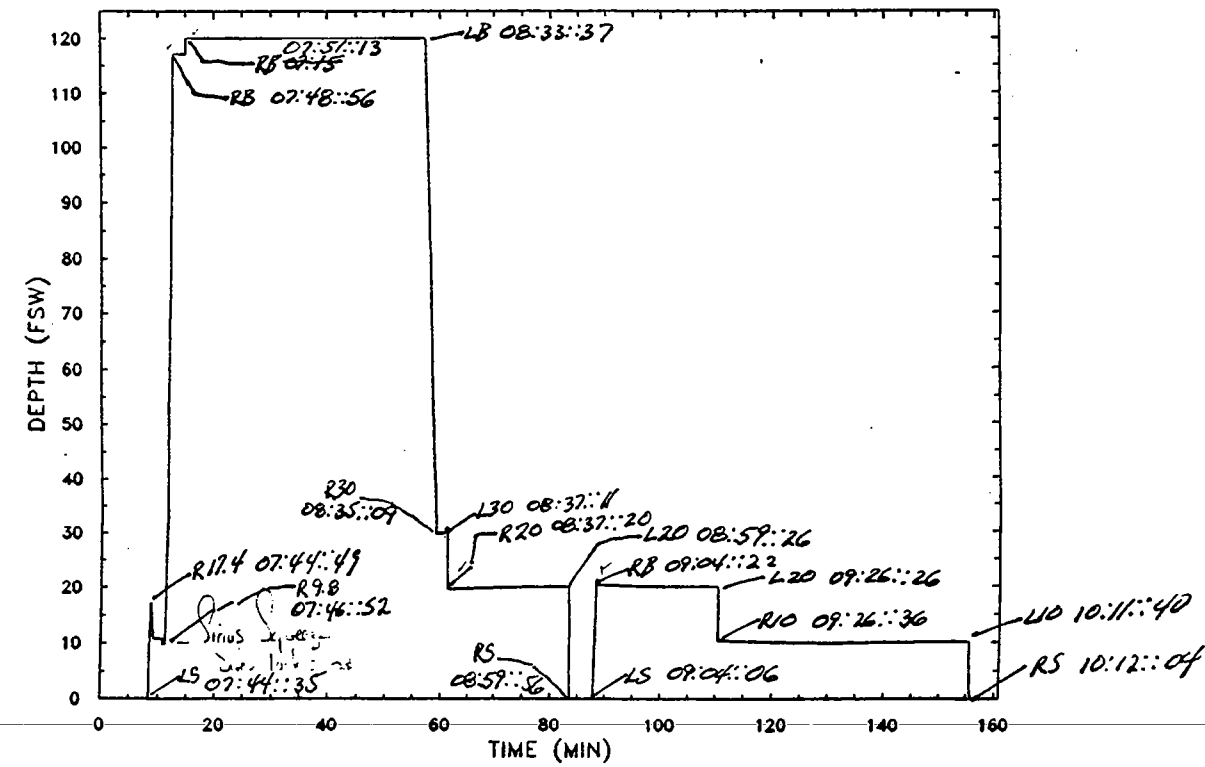
7, 8, 9 3/0

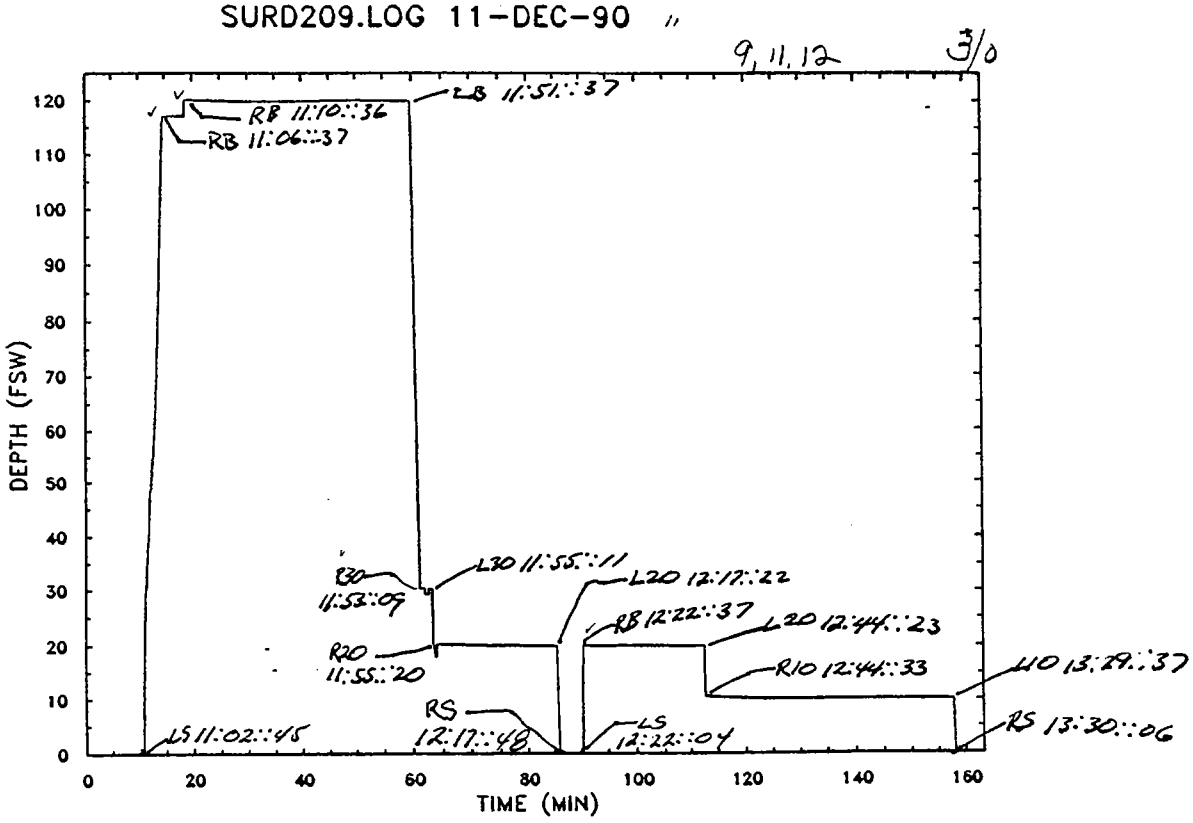


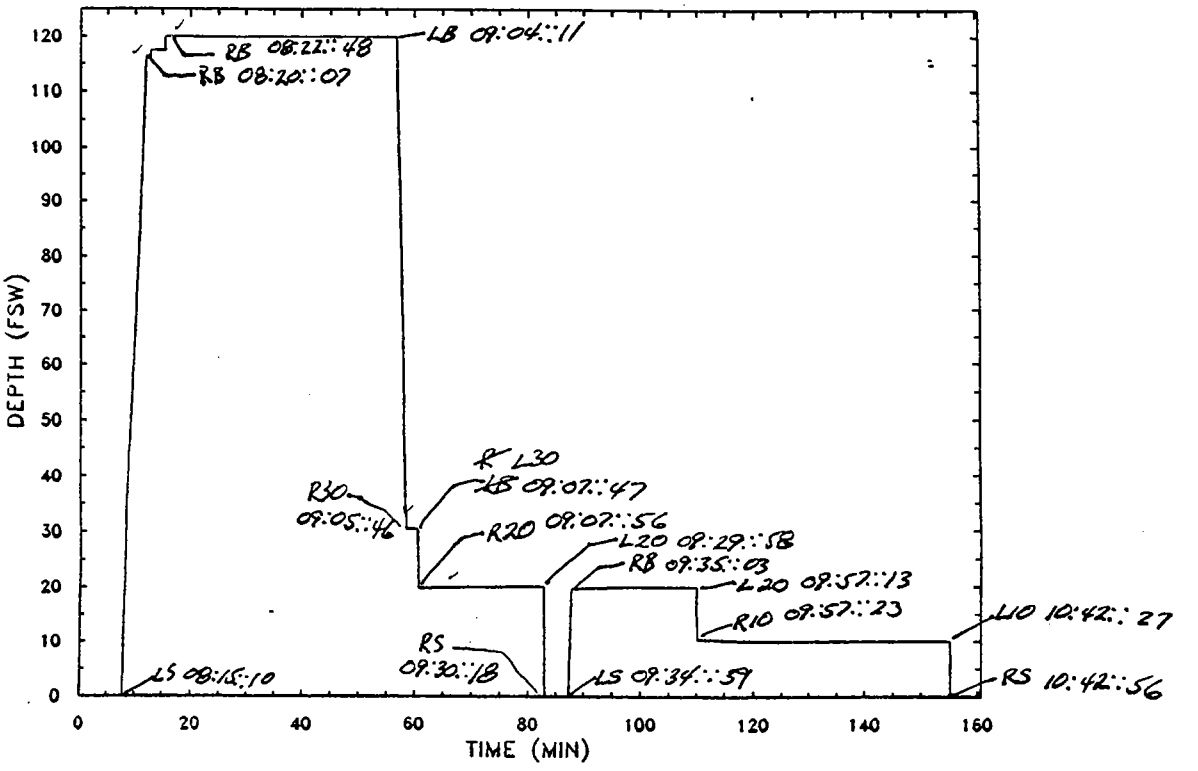
2/0

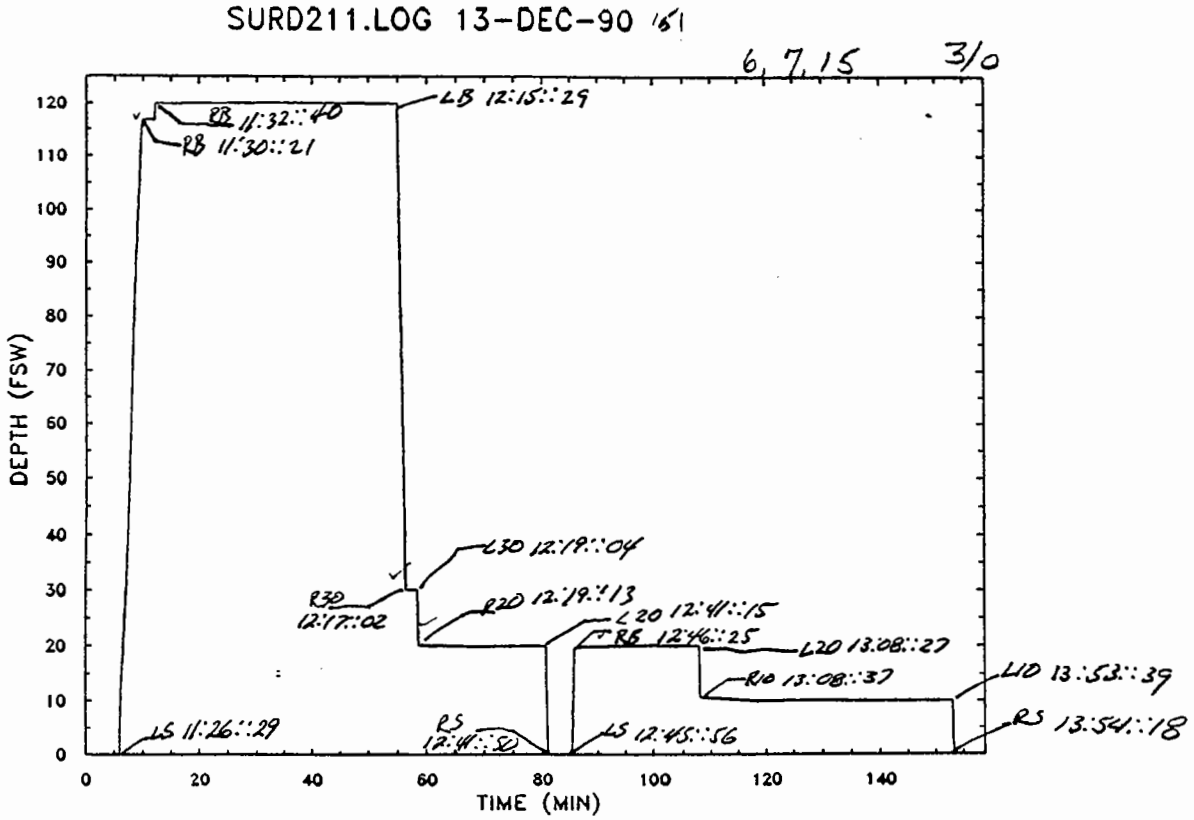
did not comp 6

SURD208.LOG 11-DEC-90




SURD209.LOG 11-DEC-90
DEPTH (FSW)
TIME (MIN)
RB 11:10::36
RB 11:06::37
LB 11:51::37
R30 11:53::09
L30 11:55::11
L20 12:17::22
RB 12:22::37
L20 12:44::23
R20 11:55::20
R10 12:44::33
L10 13:29::37
RS 12:17::48
LS 11:02::45
LS 12:22::04
RS 13:30::06


SURD 210.LOG 13-DEC-90
DEPTH (FSW)
TIME (MIN)
RB 08:22::48
RB 08:20::07
LB 09:04::11
R L30
LB 09:07::47
R30 09:05::46
R20 09:07::56
L20 09:29::58
RB 09:35::03
L20 09:52::13
R10 09:57::23
L10 10:42::27
RS 09:30::18
LS 09:15::10
LS 09:34::59
RS 10:42::56


SURD211.LOG 13-DEC-90
6,7,15
3/0
DEPTH (FSW)
TIME (MIN)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
20
40
60
80
100
120
140
LB 12:15::29
RB 11:32::40
RB 11:30::21
L30 12:19::04
R30 12:17::02
R20 12:19::13
L20 12:41::15
RB 12:46::25
L20 13:08::27
R10 13:08::37
L10 13:53::39
R5 13:54::18
LS 11:26::29
R5 12:41::50
LS 12:45::56

b. Dive profile extract

Dive profile extract, Dives SURD201 through SURD211, 120 fsw/50 min, Sur-D/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
4, 26, 34	90NOV19	SURD201	08:45::29	46.398	LS	0.0	Computer says 0.2
			08:51::30	52.448	RB	116.8	
			08:54::00	64.982	RB	119.9	
			09:36::00	96.936	R30	30.8	
				97.842		30.8	Handwritten time
				97.854		29.8	
				98.993	L30	29.8	
			09:38::11	99.134	R20	20.4	
				99.161		19.2	
				99.233		20.3	
				109.244	+10	20.0	
				119.252	+20	20.0	
				121.171	L20	20.0	
			10:00::34	121.537	RS	0.0	
			10:04::55	125.901	LS	0.0	
			10:05::57	126.771	R20	19.5	
				136.77	+10	20.0	
				146.783	+20	20.1	
				148.818	L20	20.1	
			10:27::08	148.983	R10	10.7	
				158.994	+10	10.0	
			11:12::12	194.066	L10	9.9	
			11:12::24	194.259	RS	0.0	Computer says 0.6
24, 32, 35	90NOV19	SURD202	12:07::06	4.386	LS	0.0	Computer says 0.1
			12:12::24	9.693	RB	116.6	
			12:14::20	11.632	RB	120.0	
				21.651	+10	120.0	
				31.659	+20	120.2	
				41.666	+30	120.0	
			12:56::07	53.412	LB	120.1	
			12:57::41	54.971	R30	30.1	
				55.044		30.1	
				55.066		31.2	
				55.228		31.2	
				55.250		30.2	
				57.012		30.2	
			12:59::51	57.155	R20	20.7	
				57.183		19.5	
				57.501		19.5	
				57.523		20.5	
				67.534	+10	19.9	
			13:21::55	79.237	L20	19.9	
			13:22::15	79.575	RS	0.0	Computer says 0.8
			13:26::26	83.937	LS	0.0	Computer says 0.8
			13:27::06	84.620	R20	20.0	
			13:49::18	106.833	R10	10.1	
			14:34::24	152.115	RS	0	Computer says 0.3

Dive profile extract, Dives SURD201 through SURD211, 120 fsw/50 min, Sur-D/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
1, 2, 19	90NOV19	SURD203	15:03:55	0.000	LS	0	
			15:09::21	9.355	RB	116.5	
				11.318	L	116.5	
			15:10::20	11.340	RB	120.0	
				21.347	+10	120.0	
				31.354	+20	120.2	
				41.360	+30	120.0	
				51.367	+40	120.1	
				52.936	+42	120.1	
			15:52::57	52.959	LB	119.1	
			15:54::46	54.784	R30	30.3	
			15:56::32	56.552	L30	30.3	
			15:56::45	56.778	R16.4	16.4	
				56.894		16.4	
				56.917		17.6	
				56.967		18.6	
				57.017	R20	19.8	
				67.023	+10	20.0	
				77.036	+20	20.0	
			16:18::32	78.576	L20	20.0	
			16:19::14	79.281	RS	0.0	
			16:23::15	83.309	LS	0.0	
			16:24::45	84.909	R20	20.1	
				94.921	+10	19.9	
				104.928	+20	19.9	
				106.269	L20	19.9	
			16:46::19	106.487	R10	10.0	
				116.492	+10	10.0	
				126.501	+20	10.2	
				136.507	+30	10.0	
				146.514	+40	10.0	
			17:31::20	151.505	L10	10.0	
			17:31::31	151.689	RS	0.0	Computer says 0.9
10, 28	90DEC04	SURD204	07:57::50	1.836	LS	0.0	
			08:01::31	5.528	RB	116.9	
				7.868		116.9	
			08:03::52	7.890	RB	120.1	
				17.897	+10	120.0	
				27.905	+20	120.3	
				37.923	+30	119.9	
				47.932	+40	119.9	
				50.853	LB	119.9	
			08:48::49	52.845	R30	29.8	
			08:51::09	55.203	R20	19.7	
				65.209	+10	20.1	
				75.218	+20	20.1	
			09:12::36	76.659	L20	20.1	
			09:12::59	77.043	RS	0.0	
			09:17::17	81.338	LS	0.0	
			09:17::53	81.944	R20	19.8	
				91.951	+10	20.0	

Dive profile extract, Dives SURD201 through SURD211, 120 fsw/50 min, Sur-D/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				101.959	+20	20.0	
			09:39::58	104.033	L20	20.0	
			09:40::10	104.228	R10	10.3	
				114.236	+10	10.3	
				124.243	+20	10.1	
				134.250	+30	9.9	
				144.256	+40	10.1	
			10:25::11	149.247	L10	10.1	
			10:25::25	149.473	RS	0.0	
1, 2, 3	90DEC04	SURD205	11:11::20	7.346	LS	0.0	
			11:16::56	12.948	RB	116.6	
			11:22::39	18.665	RB	120.0	
			12:02::15	58.269	R30	30.0	
			12:04::06	60.106	R20	20.6	
				70.112	+10	20.1	
				80.121	+20	20.0	
			12:26::10	82.172	L20	20.0	
			12:26::35	82.581	RS	0.0	
			12:30::54	86.899	LS	0.0	
			12:31::51	87.841	R20	20.1	
			12:54::03	110.037	R10	10.5	
				120.044	+10	10.0	
				140.068	+30	10.0	
				150.076	+10	10.1	
			13:39::06	155.085	L10	10.1	
			13:39::23	155.365	RS	0.0	
4, 5, 6	90DEC06	SURD206	08:05::30	3.130	LS	0.0	
			08:10::23	8.009	RB	116.9	
				10.304		116.9	
			08:12::42	10.327	RB	120.0	
				20.339	+10	120.0	
				30.346	+20	120.0	
				40.355	+30	119.9	
				50.363	+40	120.1	
			08:54::33	52.170	LB	120.1	
			08:56::05	53.699	R30	30.8	
				54.837		30.8	
				54.860		29.8	
			08:58::06	55.711	L30	29.8	
			08:58::15	55.854	R20	20.6	
				65.862	+10	20.0	
				75.869	+20	20.0	
			09:20::18	77.900	L20	20.0	
			09:20::37	78.215	RS	0.0	Computer says 1.0
			09:25::00	82.589	LS	0.0	Computer says 1.0
			09:25::53	83.469	RB	19.6	
				83.520		20.6	
				93.3	+10	19.9	
				103.539	+20	20.1	
			09:47::38	105.547	L20	20.1	

Dive profile extract, Dives SURD201 through SURD211, 120 fsw/50 min, Sur-D/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			09:47::48	105.719	R10	10.5	
				115.724	+10	10.1	
				125.732	+20	10.0	
				135.739	+30	10.0	
				145.746	+40	9.9	
			10:32::51	150.777	L10	9.9	
			10:33::03	150.971	RS	0.0	Computer says 0.9
7, 8, 9	90DEC06	SURD207	11:15::00	3.500	LS	0.0	
			11:20::08	8.631	RB	117.2	Handwritten time
			11:23::21	11.840	RB	119.9	
			12:04::02	11.840	LB	119.9	
			12:05::34	54.052	R30	30.9	
				54.390		30.9	
				54.413		29.8	
				56.086		29.8	
			12:07::44	56.225	R20	20.3	
				66.231	+10	20.0	
				76.240	+20	19.9	
			12:29::47	78.274	L20	19.9	
			12:30::12	78-683	RS	0.0	
			12:34::28	82.956	LS	0.0	
			12:35::05	83.583	RB	20.2	
				93.595	+10	20.0	
				103.603	+20	19.9	
			12:57::07	105.610	L20	19.9	
			12:57::17	105.783	R10	10.4	
				115.790	+10	10.0	
				125.799	+20	10.0	
				135.806	+30	10.2	
				145.818	+40	10.0	
			13:42::20	150.827	L10	10.0	
			13:42::32	151.019	RS	0.0	Computer says 0.5
8, 10	90DEC11	SURD208	07:44::35	8.339	LS	0.0	
			07:44::49	8.575	R17.4	17.4	Ear block
			07:46::52	10.630	R9.8	9.8	Diver locked out
			07:48::56	12.695	RB	117.2	
			07:51::13	14.971	RB	120.0	
			08:33::37	57.376	LB	120.1	
			08:35::09	58.912	R30	29.9	
				60.545		29.9	
				60.562		30.9	
				60.945		30.9	
			08:37::20	61.097	R20	20.8	Handwritten time
				61.115		19.6	
				71.116	+10	19.9	
				81.116	+20	20.0	
			08:59::26	83.199	L20	20.0	
			08:59::56	83.705	RS	0.0	
			09:04::06	87.873	LS	0.0	
			09:04::22	88.143	RB	19.9	

Dive profile extract, Dives SURD201 through SURD211, 120 fsw/50 min, Sur-D/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				88.176		21.3	
				88.393		21.3	
				88.409		20.3	
				98.409	+10	20.0	
				108.414	+20	20.0	
			09:26::26	110.214	L20	20.0	
			09:26::36	110.384	R10	10.4	
				120.385	+10	10.0	
				130.385	+20	9.9	
				140.385	+30	10.0	
				150.385	+40	10.1	
			10:11::40	155.452	L10	10.1	
			10:12::04	155.857	RB	0.0	Computer says 0.2
9, 11, 12	90DEC11	SURD209	11:02::45	10.752	LS	0.0	
			11:06::37	14.679	RB	117.1	
			11:10::36	18.662	RB	120.2	
				28.662	+10	119.9	
				38.679	+20	119.9	
				48.683	+30	120.2	
				58.684	+40	120.0	
			11:51::37	59.785	LB	120.0	
			11:53::09	61.311	R30	30.3	
				62.197		30.3	
				62.213		29.3	
				62.797		29.3	
				62.814		30.3	
			11:55::11	63.397	L30	30.3	
			11:55::20	63.550	R20	20.2	
				63.650		20.2	
				63.667		19.2	
				63.819		19.2	
				63.836		18.0	
				64.002		18.0	
				64.019		19.1	
				64.086		20.3	
				74.086	+10	20.1	
				84.091	+20	20.0	
			12:17::22	85.591	L20	20.0	
			12:17::48	86.030	RS	0.0	
			12:22::04	90.299	LS	0.0	
			12:22::37	90.856	RB	21.0	
			12:44::33	112.793	R10	10.6	
				122.796	+10	10.1	
				132.796	+20	10.1	
				142.797	+30	10.1	
				152.797	+40	10.1	
			13:29::37	157.863	L10	10.1	
			13:30::06	158.342	RS	0.0	Computer says 0.1
2, 13, 14	90DEC13	SURD210	08:15::10	7,854	LS	0.0	
			08:20::07	12.801	RB	116.4	Handwritten time

Dive profile extract, Dives SURD201 through SURD211, 120 fsw/50 min, Sur-D/air

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				12.810		117.4	
				15.460		117.4	
			08:22::48	15.477	RB	120.0	
			09:04::11	56.866	LB	120.0	
			09:05::46	58.445	R30	30.4	
			09:07::56	60.614	R20	19.8	
				70.614	+10	20.0	
				80.614	+20	20.1	
			09:29::58	82.648	L20	20.1	
			09:30::18	82.988	RS	0.0	
			09:34::39	87.340	LS	0.0	
			09:35::03	87.747	RB	19.7	
				97.750	+10	20.0	
				107.750	+20	20.0	
			09:57::13	109.917	L20	20.0	
			09:57::23	110.087	R10	10.4	
				120.087	+10	10.0	
				130.087	+20	10.0	
				140.087	+30	10.0	
				150.087	+40	10.0	
			10:42::27	155.154	L10	10.0	
			10:42::56	155.644	RS	0.0	Computer says 0.6
6, 7, 15	90DEC13	SURD211	11:26::29	5.903	LS	0.0	
			11:30::21	9.769	RB	116.7	
			11:32::40	12.085	RB	119.9	
				22.087	+10	120.0	
				32.087	+20	120.2	
				42.092	+30	120.1	
				52.092	+40	120.0	
			12:15::29	54.909	LB	120.0	
			12:17::02	56.452	R30	30.1	
			12:19::13	58.641	R20	20.1	
				68.641	+10	19.1	
				78.642	+20	20.0	
			12:41::15	80.676	L20	20.0	
			12:41::50	81.021	RS	0.0	
			12:45::56	81.254	LS	0.0	
			12:46::25	85.844	RB	19.8	
				95.844	+10	20.1	
				105.848	+20	20.0	
			13:08::27	107.882	L20	20.0	
			13:08::37	108.021	R10	10.7	
				118.055	+10	10.0	
				128.055	+20	10.1	
				138.056	+30	10.0	
				148.056	+40	10.0	
			13:53::39	153.089	L10	10.0	
			13:54::18	153.744	RS	0.0	Computer says 0.2

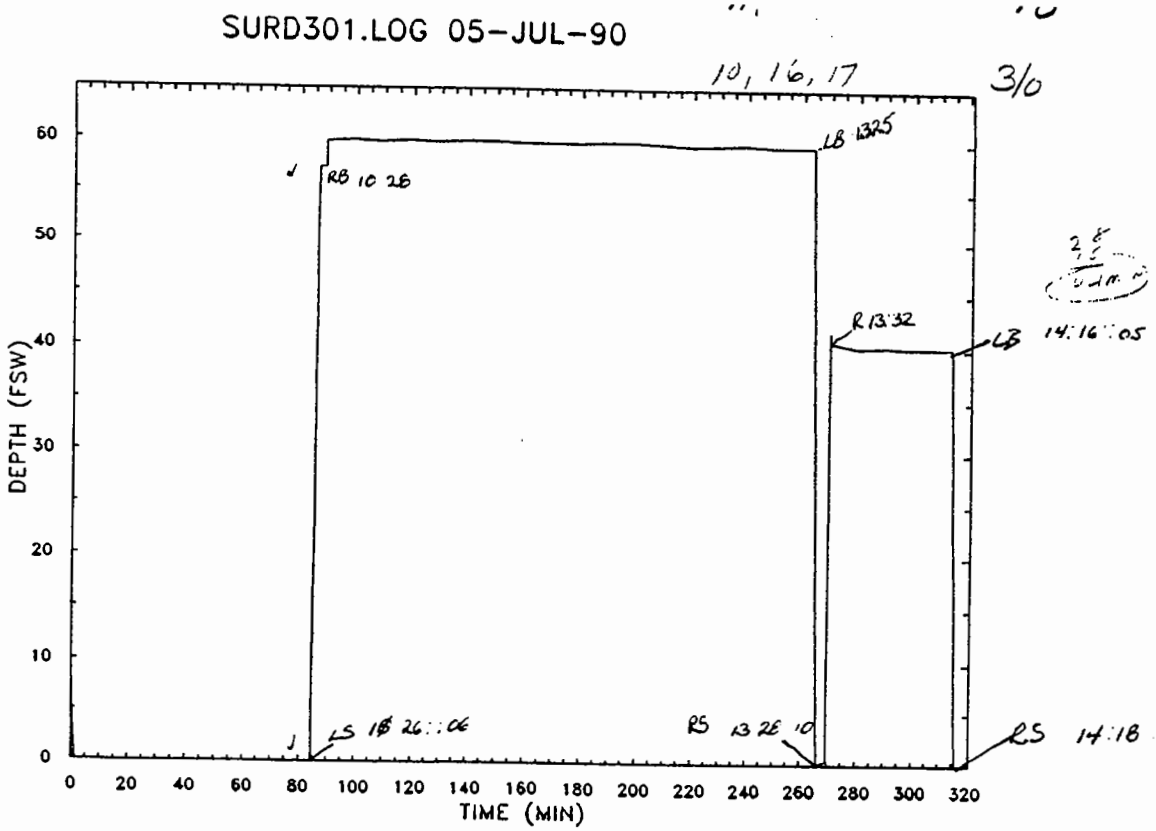
There are no medical reports for this group.

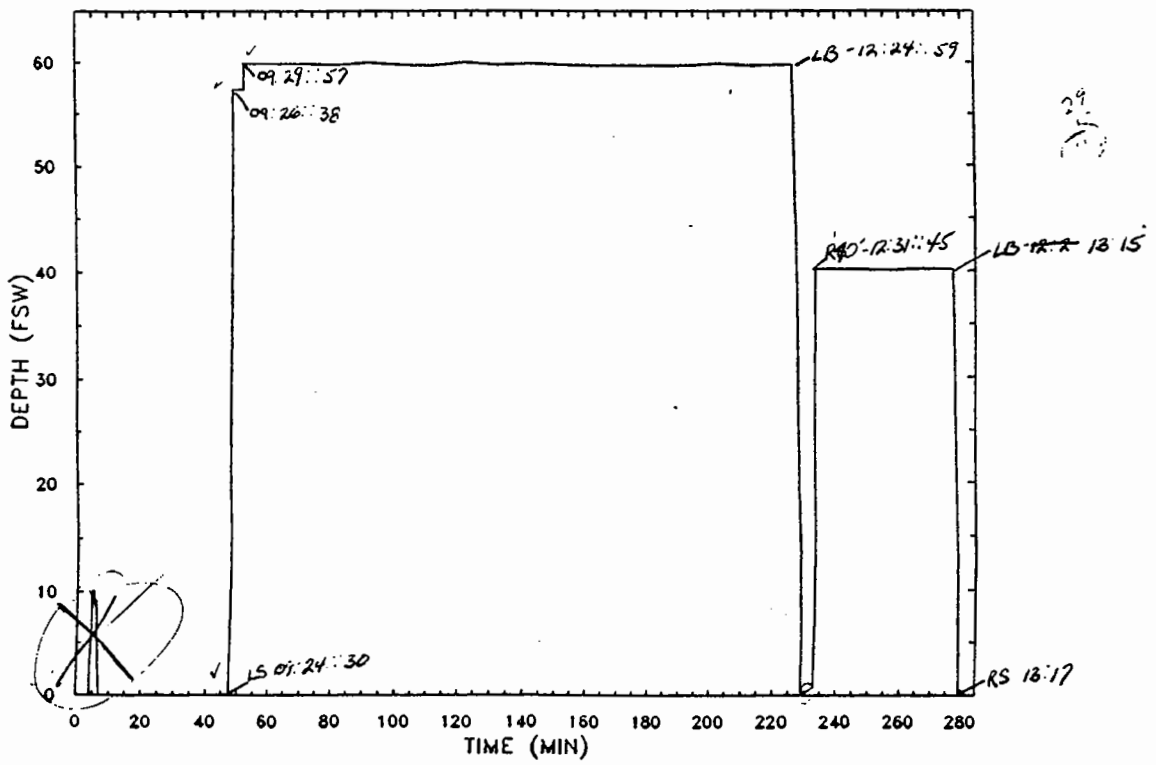
4. Group 3, 60 fsw/180min with Sur-D/O_2, Dives SURD301 through SURD306.

a. Graphic plots

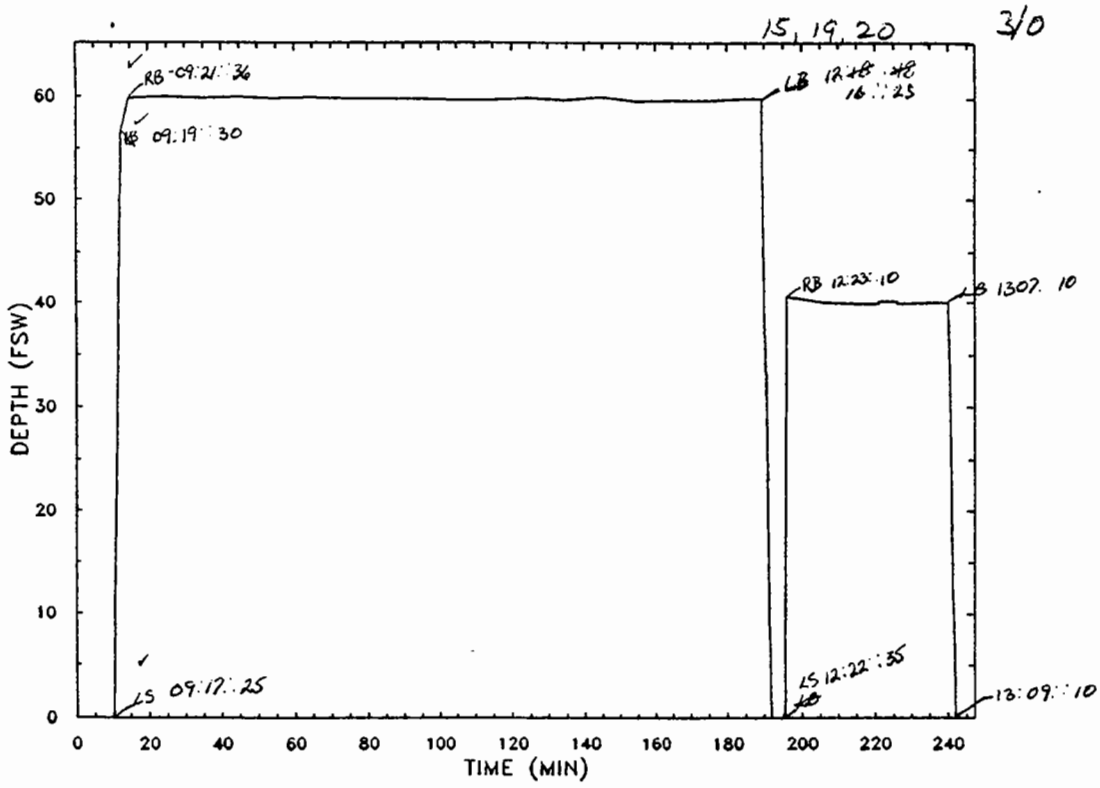
The graphic profiles follow.

Graphic plots, Dives SURD301 through SURD306, 60 fsw/180 min, Sur-D/O_2



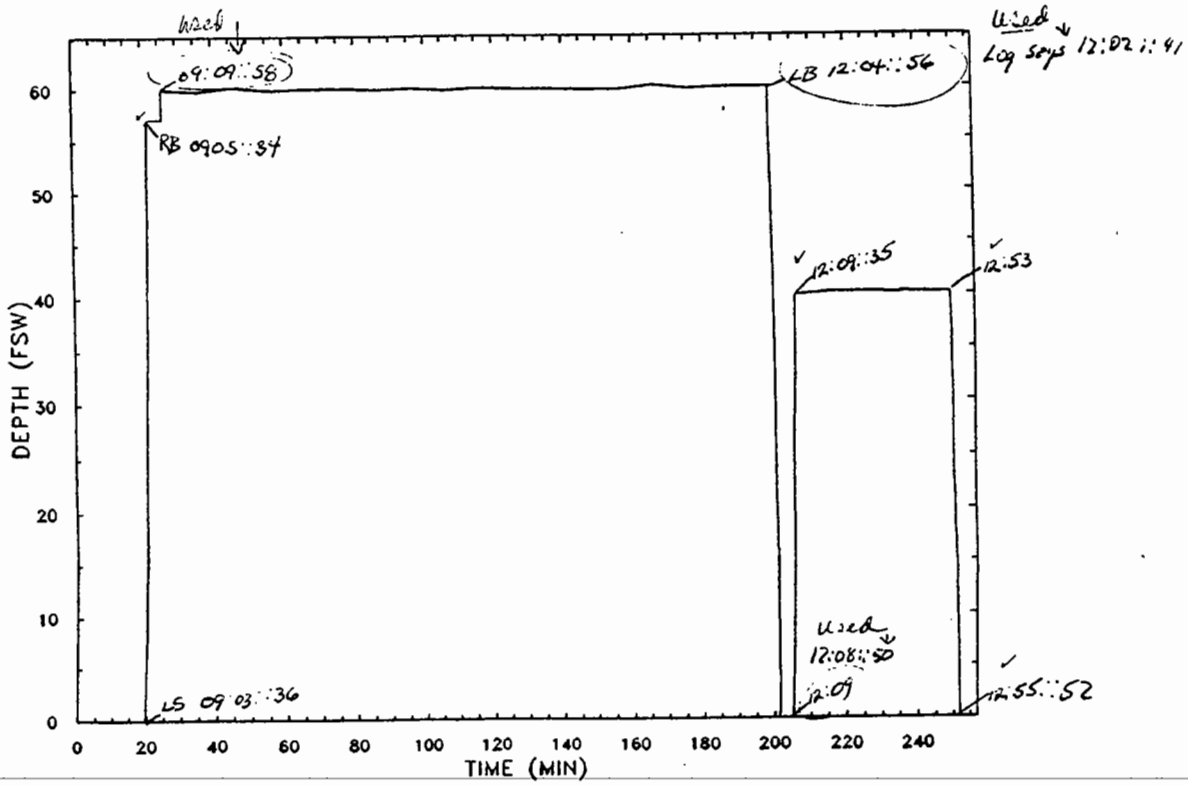


SURD303.LOG 09-JUL-90

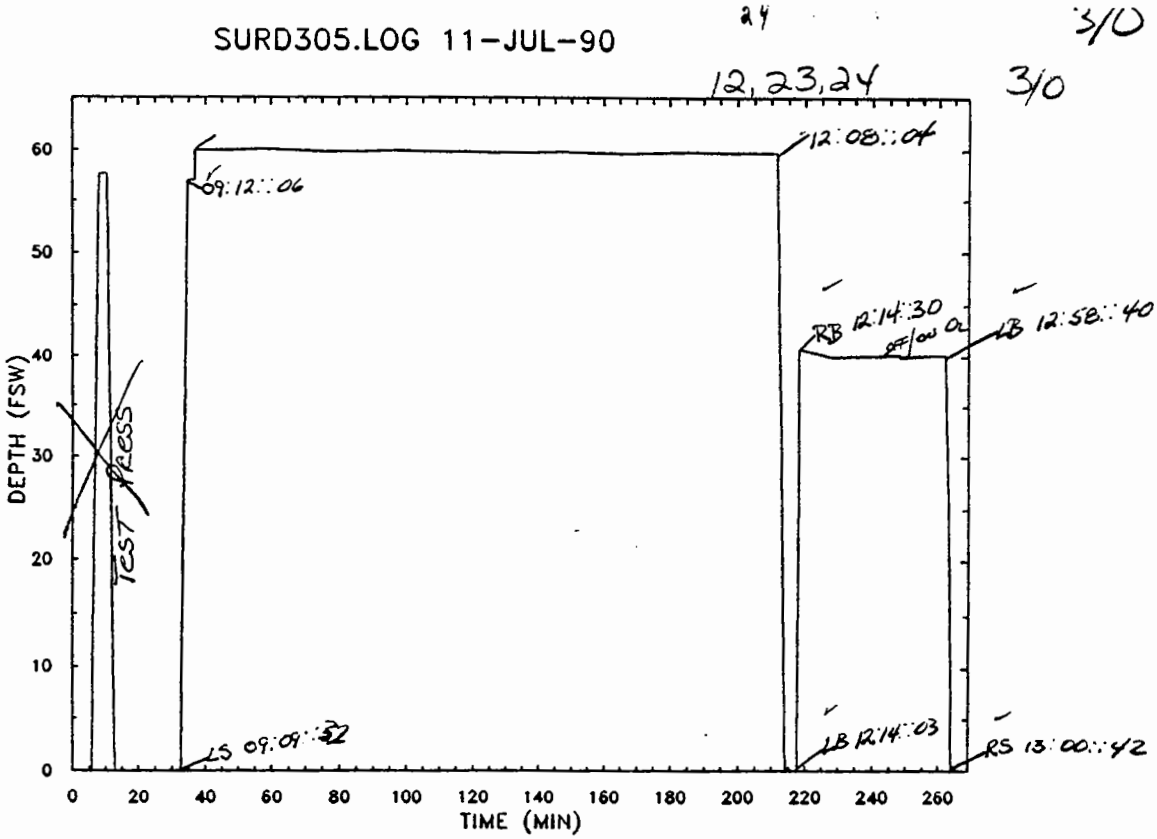


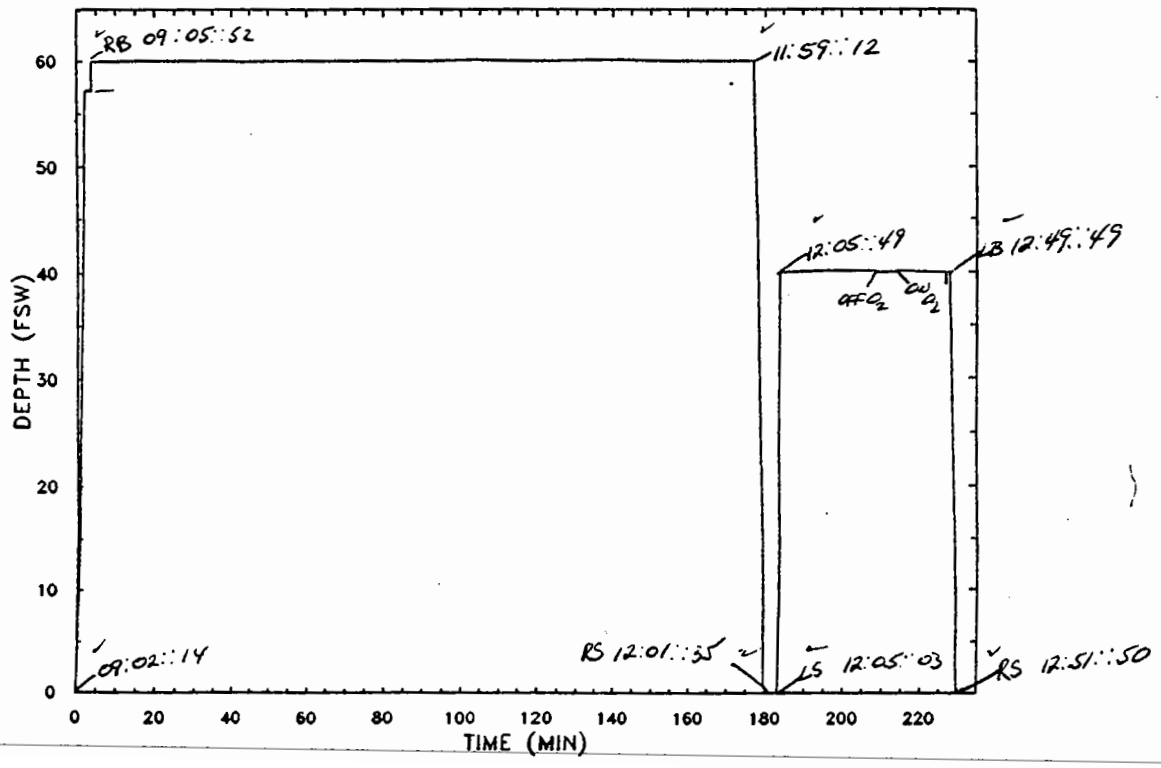
3/0

SURD304.LOG 10-JUL-90



Graphic plots, Dives SURD301 through SURD306, 60 fsw/180 min, Sur-D/O_2





Dive profile extract, Dives SURD301 through SURD306, 60 fsw/180 min, Sur-D/O_2

b. Dive profile extract

Dive profile extract, Dives SURD301 through SURD306, 60 fsw/180min, Sur-D/O_2,

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
10, 16, 17	90JUL05	SURD301	10:26::06	84.492	LS	0.0	
			10:28::00	88.665	RB	57.4	
			10:30::17	88.684	RB	59.9	
				98.699	+10	60.0	
				108.714	+20	59.9	
				118.714	+30	60.0	
				128.717	+40	59.9	
				138.722	+50	60.0	
				148.738	+60	60.0	
				158.753	+70	59.9	
				168.770	+80	59.9	
				178.788	+90	59.9	
				188.803	+100	60.0	
				198.821	+110	60.0	
				208.838	+120	59.9	
				218.842	+130	59.7	
				228.856	+140	59.8	
				238.872	+150	59.9	
				248.890	+160	59.7	
				258.891	+170	59.7	
			13:25::	263.540	LB	59.7	
			13:28::10	266.119	RS	0.0	
			13:31::57	269.562	LS; on O_2	0.4	
			13:32::	269.972	RB	41.7	
				270.091		41.7	
				270.111		40.7	
				280.113	+10	40.2	
				290.130	+20	40.3	
			13:57	295.207	Off O_2	40.2	
			14:02	299.991	On O_2	40.2	
				310.006		40.2	
			14:16::05	314.050	LB	40.2	
			14:18::00	315.964	RS, off O_2	0.0	
8, 9, 18	90JUL06	SURD302	09:24::30	47.362	LS	0.0	
			09:26::38	49.438	RB	56.3	
				49.476		57.4	
				52.763		57.4	
			09:29::57	52.783	R60	59.9	
				62.797	+10	59.9	
				72.814	+20	59.9	
				82.830	+30	59.8	
				92.844	+40	60.0	
				102.848	+50	59.8	
				112.864	+60	59.7	
				122.883	+70	60.0	
				132.899	+80	59.8	
				142.901	+90	59.9	
				152.917	+100	59.8	

Dive profile extract, Dives SURD301 through SURD306, 60 fsw/180 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				162.933	+110	59.7	
				172.948	+120	59.7	
				182.966	+130	59.7	
				192.983	+140	59.7	
				202.988	+150	59.9	
				213.006	+161	59.7	
				223.023	+171	59.8	
			12:24::59	226.467	LB	59.8	
			12:27::40	229.172	RS	0.0	
			12:31::18	232.821	LS; on O_2	0.0	Computer says 0.8
			12:31::45	233.271	R40	40.2	
				243.272	+10	40.2	
				253.272	+20	40.1	
			12:56::49	258.360	Off O_2	40.1	
			13:01	263.345	On O_2	40.2	
				273.357	+40	40.2	
			13:15	277.364	LB	40.2	
			13:17	279.242	RS	0.0	
15, 19, 20	90JUL09	SURD303	09:17::25	10.277	LS	0.0	
			09:19::30	12.314	RB	56.6	
			09:21::34	14.446	RB	59.9	
				24.447	+10	60.0	
				34.447	+20	59.9	
				44.450	+30	60.0	
				54.451	+40	59.9	
				64.452	+50	60.0	
				74.457	+60	59.9	
				84.467	+70	59.9	
				94.480	+80	59.9	
				104.484	+90	59.8	
				114.489	+100	59.8	
				124.490	+110	60.0	
				134.510	+120	59.8	
				144.513	+130	60.1	
				154.534	+140	59.7	
				164.556	+150	59.8	
				174.558	+160	59.8	
				184.568	+170	60.0	
			12:16::25	189.277	LB	60.0	
			12:19::10	194.014	RS	0.0	
				195.460	On O_2	0.0	
			12:22::36	195.480	LS	0.2	
			12:23::06	195.983	RB	40.6	
				205.989	+10	40.0	
				215.995	+20	39.9	
				220.998	+25	39.9	
			12:48::08	221.020	Off O_2	40.1	
				225.976	+30	40.1	
			12:53	225.998	On O_2	39.9	
				236.015	+41	40.0	
			13:07::00	240.069	LB	40.0	

Dive profile extract, Dives SURD301 through SURD306, 60 fsw/180 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			13:09::00	242.152	RS	0.0	
7, 21, 22	90JUL10	SURD304	09:03::36	19.775	LS	0.0	
			09:05::34	21.753	RB	57.1	
			09:09::58	26.043	RB	60.0	
				36.064	+10	59.8	
				46.068	+20	60.2	
				56.080	+30	59.9	
				66.084	+40	60.0	
				76.095	+50	60.0	
				86.098	+60	59.9	
				96.098	+70	60.0	
				106.098	+80	59.8	
				116.099	+90	60.0	
				126.099	+100	59.9	
				136.102	+110	59.9	
				146.109	+120	59.8	
				156.110	+130	59.8	
				166.112	+140	60.2	
				176.133	+150	59.9	
				186.134	+160	60.0	
				196.136	+170	60.0	
			12:02::41	198.868	LB	60.0	
			12:05::24	201.653	RS	0.0	
			12:08::50	205.097	LS	0.0	
				205.119	On O_2	0.5	
			12:09::35	205.644	RB	39.9	
				215.665	+10	40.2	
				225.667	+20	40.2	
				230.683		40.2	
			12:34::38	230.705	Off O_2	40.1	
				235.687	+30	40.1	
			12:39::38	235.710	On O_2	40.2	
				245.712	+40	40.1	
			12:53::44	249.820	LB	40.1	
			12:55::52	251.966	RS	0.0	
12, 23, 24	90JUL11	SURD305	09:09::32	32.592	LS	0.0	
			09:12::06	34.592	RB	57.0	
			09:13::33	36.879	RB	60.0	
				46.899	+10	60.0	
				56.901	+20	60.1	
				66.906	+30	60.0	
				76.927	+40	59.9	
				86.948	+50	59.9	
				96.949	+60	60.0	
				106.949	+70	59.9	
				116.950	+80	59.9	
				126.954	+90	59.8	
				136.961	+100	59.8	
				146.983	+110	59.9	
				156.987	+120	59.8	

Dive profile extract, Dives SURD301 through SURD306, 60 fsw/180 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				166.989	+130	59.7	
				176.989	+140	59.8	
				187.008	+150	59.9	
				197.030	+160	59.8	
				207.039	+170	59.8	
			12:08::04	211.661	LB	59.8	
			12:10::32	214.144	RS	0.0	
			12:14::03	217.674	LS/On O_2	0.1	
			12:14::30	218.125	RB	40.8	
				228.131	+10	40.0	
				238.150	+20	40.1	
				243.148		40.1	
			12:39::32	243.170	Off O_2	40.2	
				248.124	+30	40.2	
			12:44::37	248.146	On O_2	40.0	
				258.167	+40	40.2	
				262.188		40.2	
			12:58::40	262.210	LB	39.1	
			13:00::42	264.253	RS	0.0	Computer says 0.1
4, 6, 17	90JUL12	SURD306	09:02::14	0.000	LS	2.0	
			09:04::16	2.139	RB	57.2	
			09:05::52	3.744	RB	60.0	
				13.744	+10	60.1	
				23.745	+20	60.1	
				33.746	+30	60.0	
				43.768	+40	60.1	
				53.769	+50	60.1	
				63.774	+60	60.1	
				73.776	+70	60.1	
				83.797	+80	60.1	
				93.797	+90	60.1	
				103.819	+100	60.2	
				113.819	+110	60.1	
				123.841	+120	60.1	
				133.845	+130	60.2	
				143.846	+140	60.2	
				153.846	+150	60.1	
				163.867	+160	60.1	
				173.887	+170	60.1	
			11:59::12	177.085	LB	60.1	
			12:01::35	179.478	RS	0.0	
			12:05::03	183.119	LS	0.0	
			12:05::49	183.562	RB	40.0	
				193.563	+10	40.1	
				203.583	+20	40.1	
				208.584		40.1	
			12:30::51	208.606	Off O_2	40.0	
				213.611	+30	40.0	
			12:35::52	213.633	On O_2	40.1	
				223.654	+40	40.0	
			12:49::49	226.517	LB	40.0	

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			12:51::50	229.464	RS	0.0	Computer says 0.5

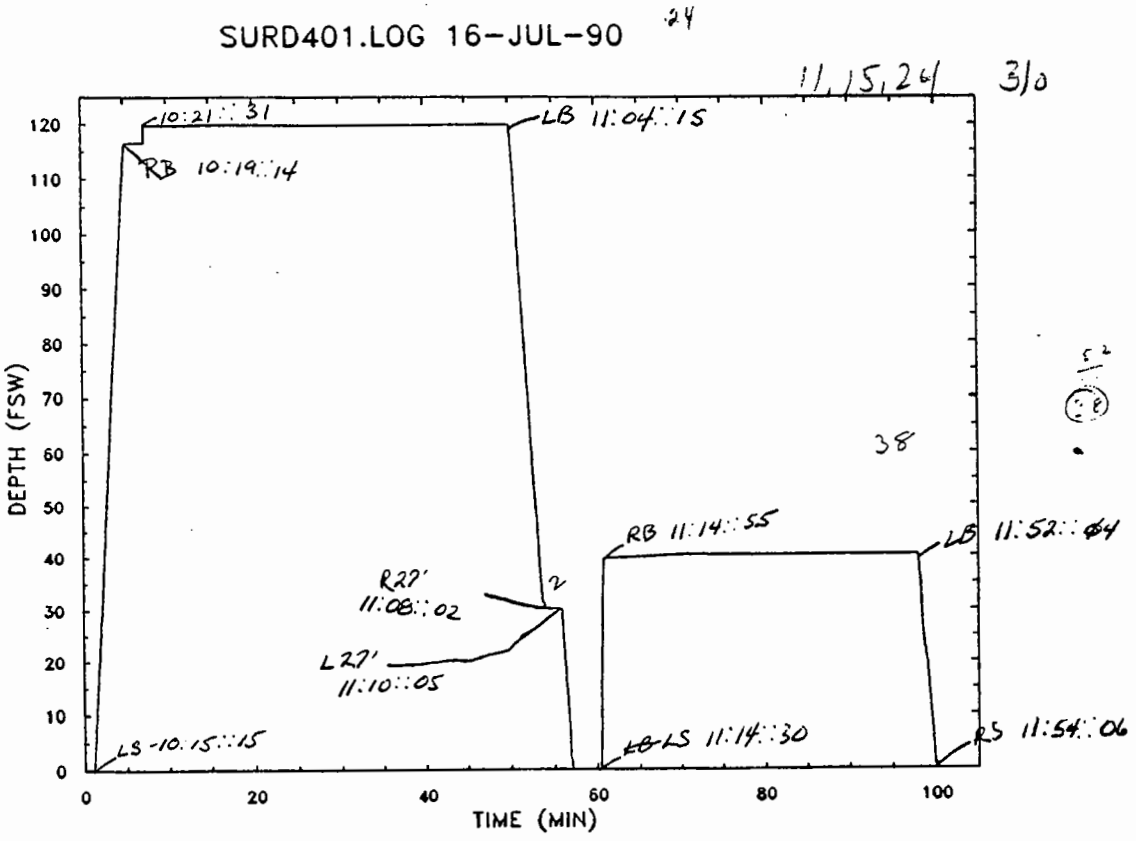
There are no medical reports for this group.

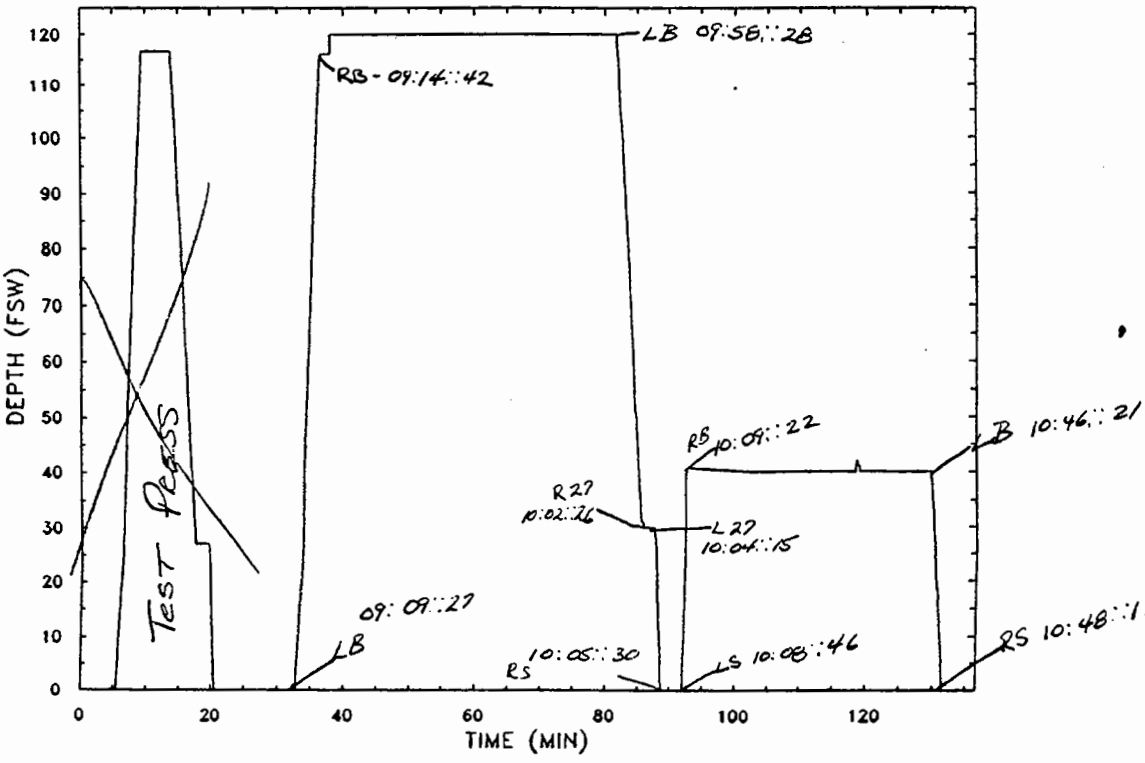
5. Group 4, 120 fsw/50 min with Sur-D/O_2, Dives SURD401 through SURD409

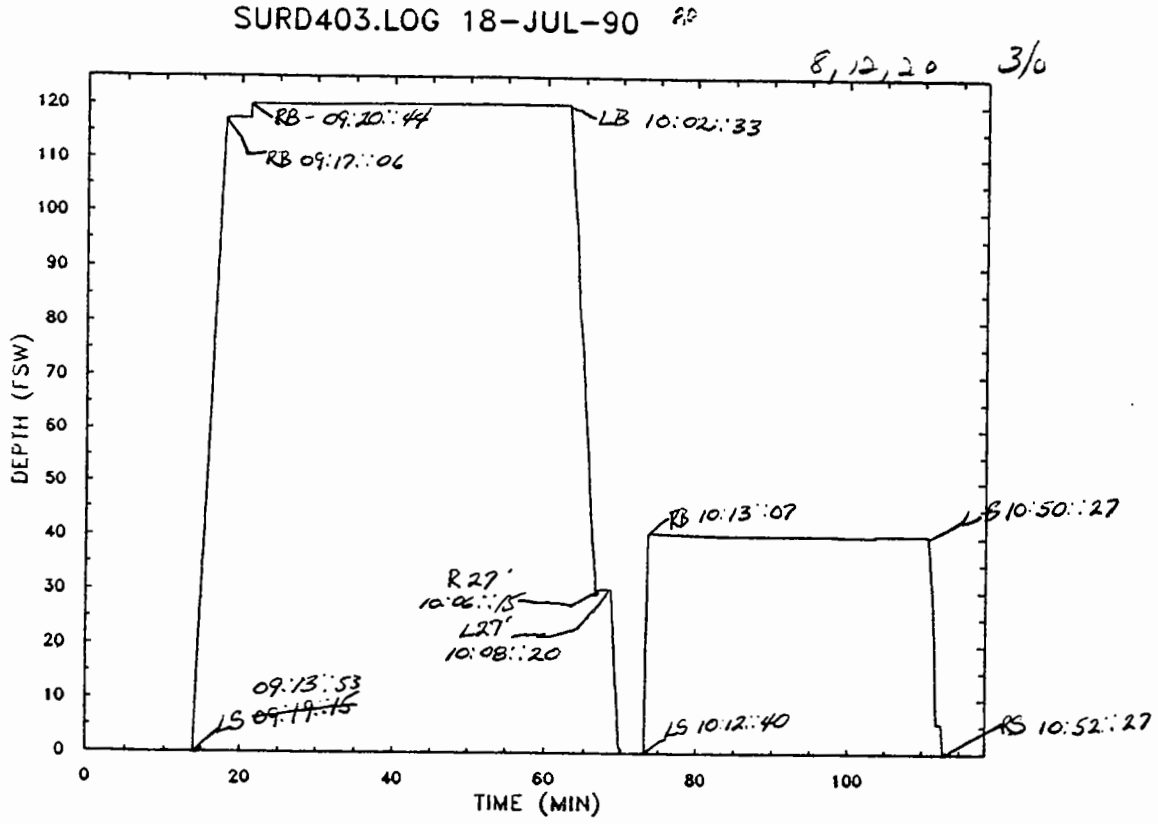
a. Graphic plots

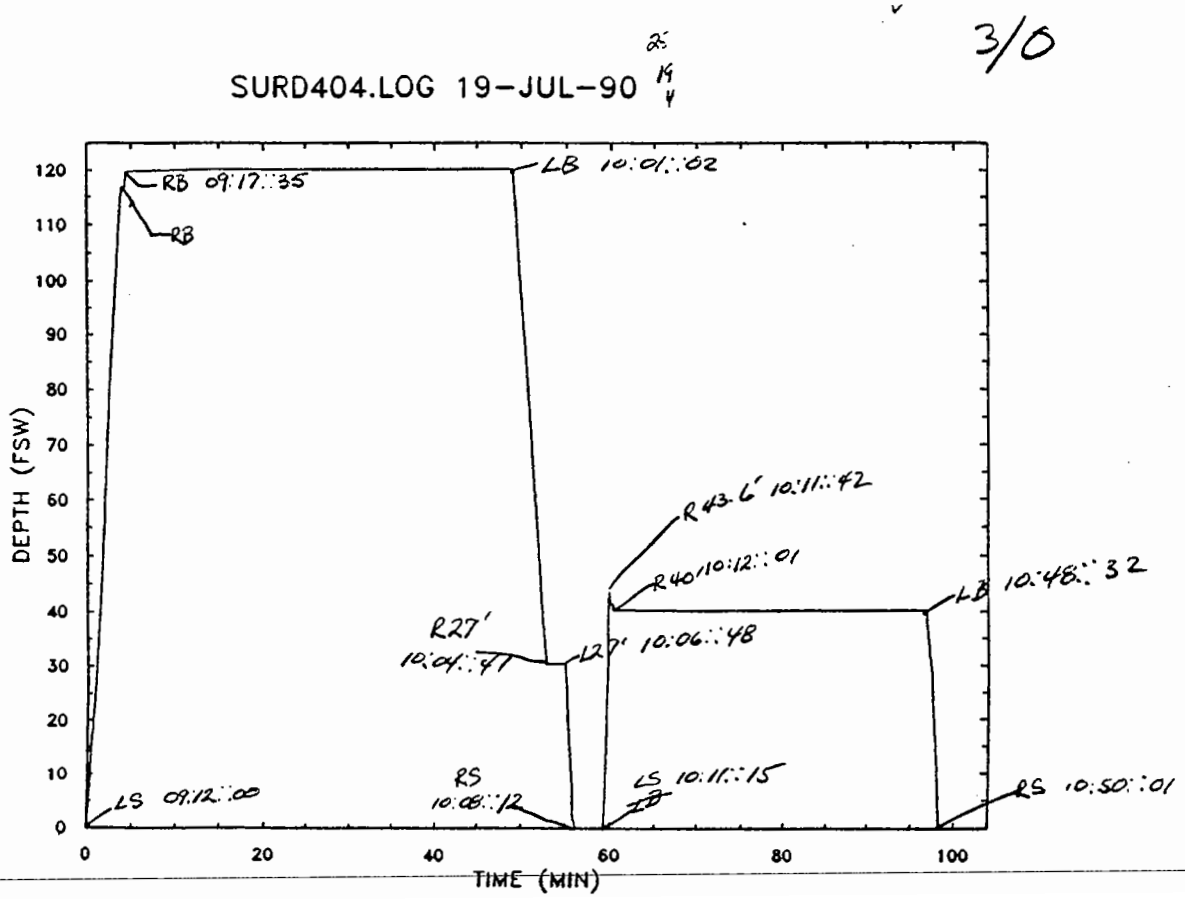
The graphic profiles follow.

Graphic plots, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2

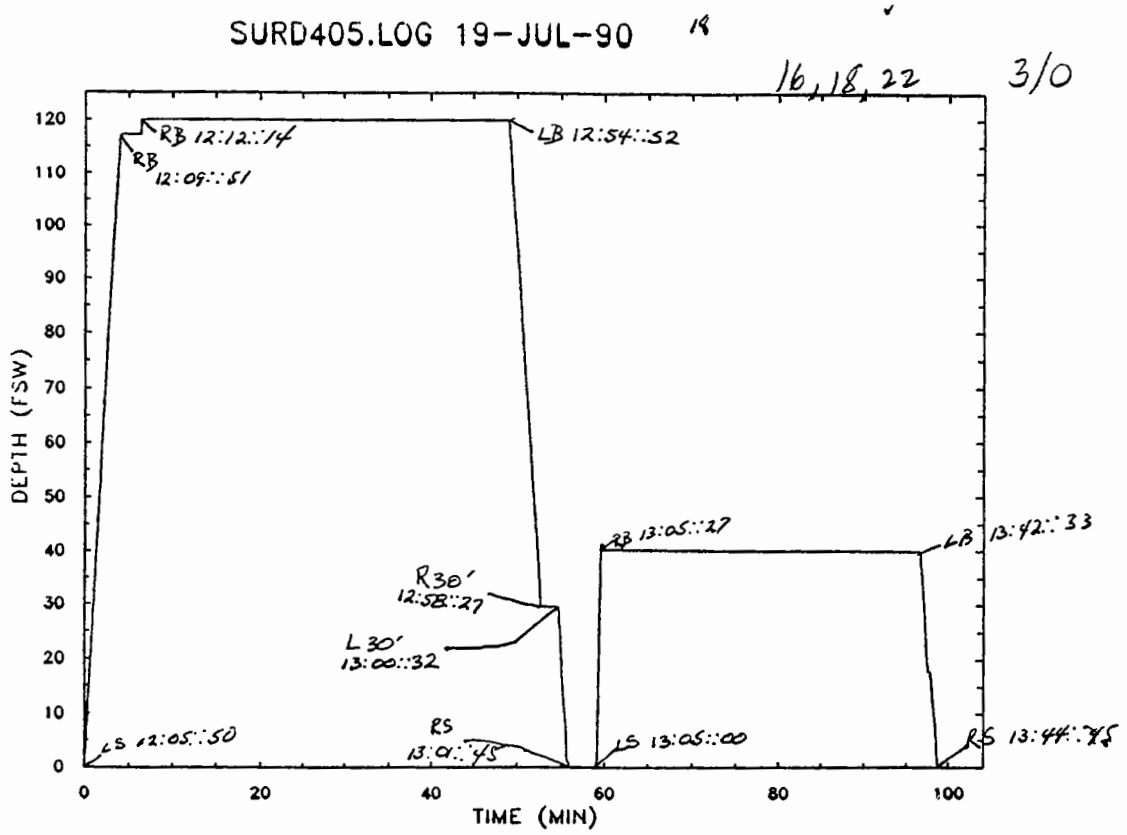


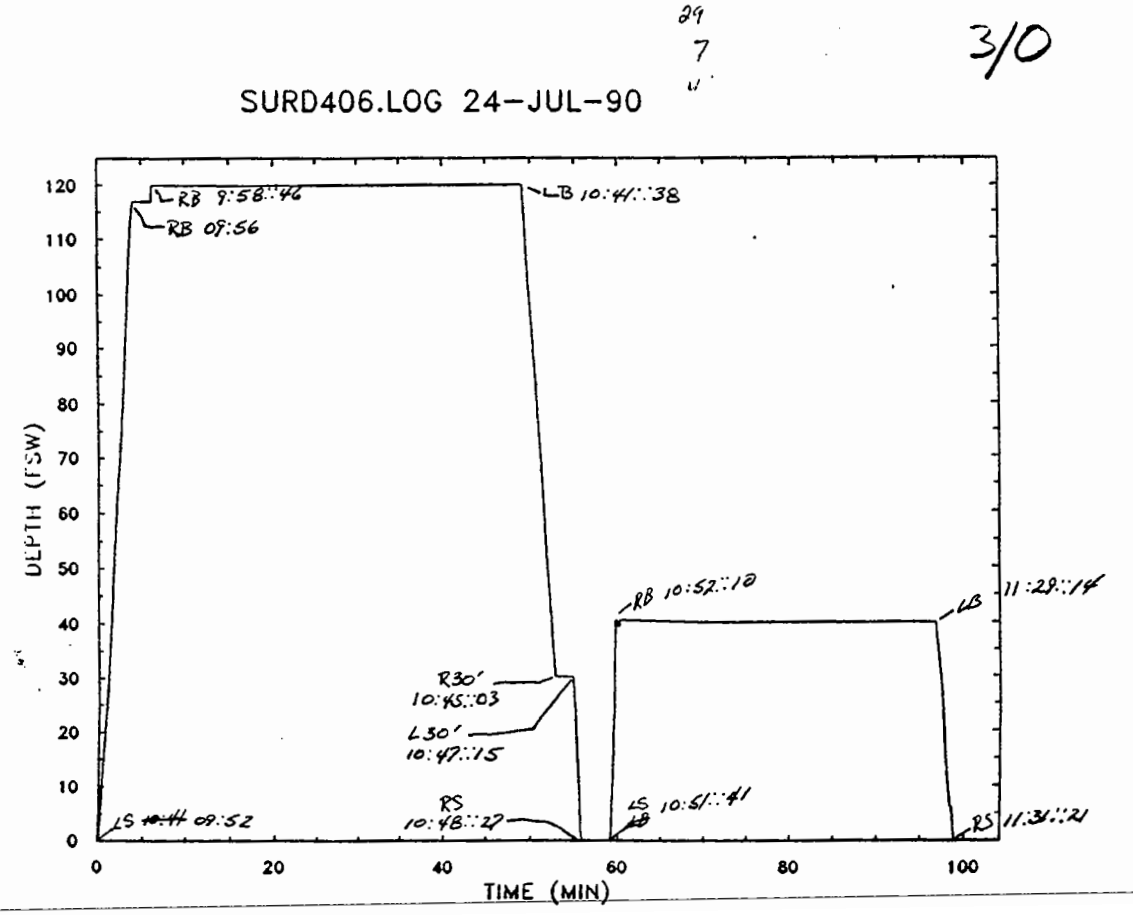



SURD403.LOG 18-JUL-90
8, 12, 20 3/0
RB - 09:20::44
RB 09:17::06
LB 10:02::33
RB 10:13::07
LS 10:50::27
R 27' 10:06::15
L 27' 10:08::20
09:13::53
LS 09:19::15
LS 10:12::40
RS 10:52::27
DEPTH (FSW)
TIME (MIN)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
20
40
60
80
100

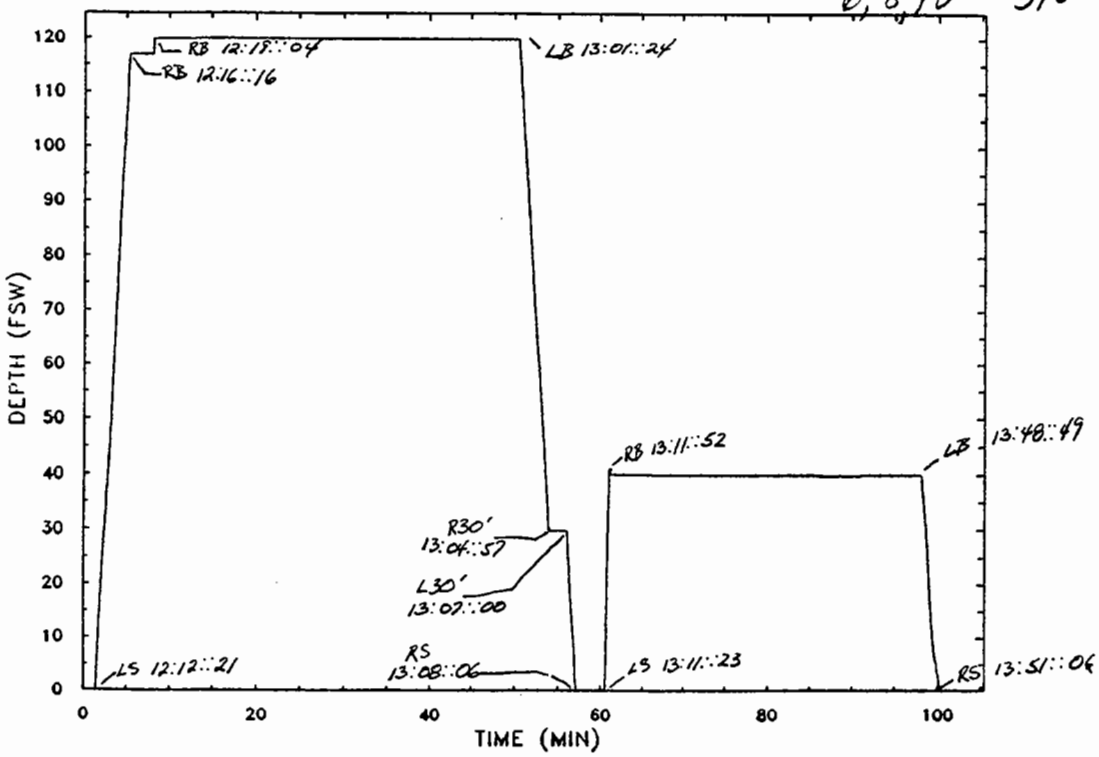

3/0
SURD404.LOG 19-JUL-90
RB 09:17::35
RB
LB 10:01::02
R 43.6' 10:11::42
R 40' 10:12::01
LB 10:48::32
R 27' 10:04::41
L 27' 10:06::48
LS 09:12::00
RS 10:08::12
LS 10:11::15
RS 10:50::01
DEPTH (FSW)
TIME (MIN)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
20
40
60
80
100

Graphic plots, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2

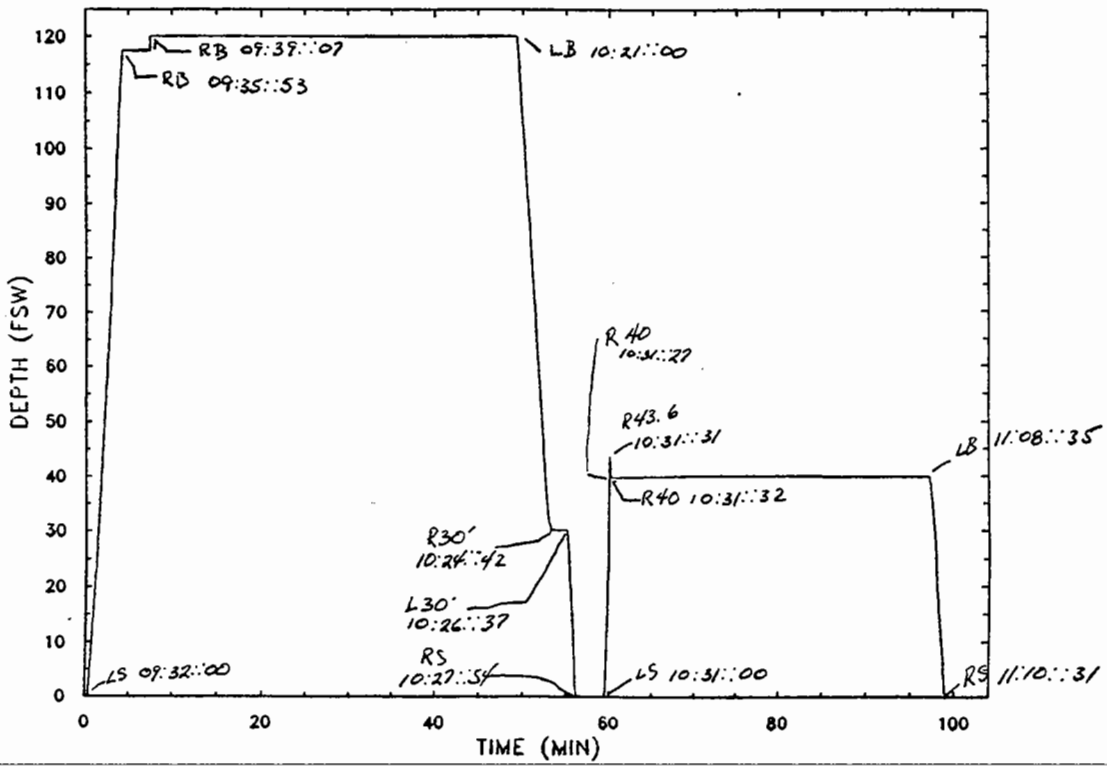




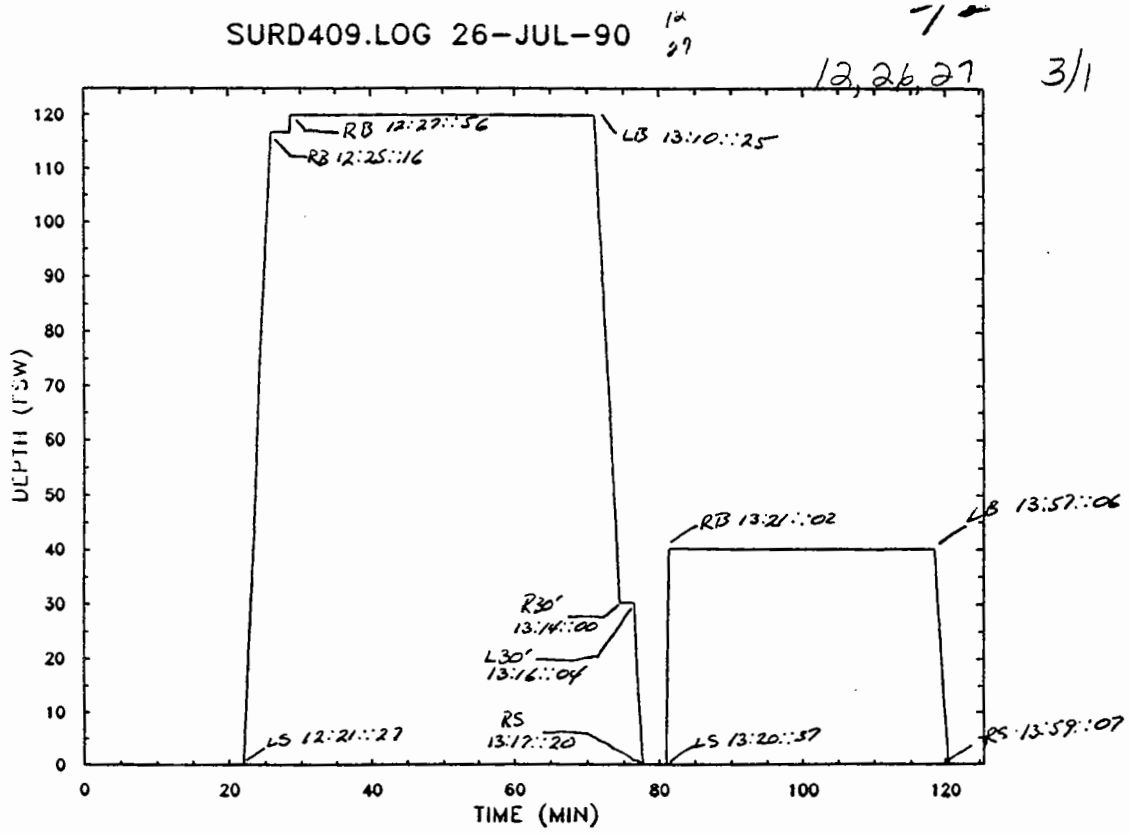
SURD407.LOG 24-JUL-90



SURD408.LOG 26-JUL-90



Graphic plots, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2



Dive profile extract, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			10:06::05	66.492	R30	30.9	Log notes say "R27," which is without the water offset.
			10:08::20	66.624	L30		
			10:09::35	69.854	RS	0.0	
			10:12::40	73.049	On O_2; LS	0.1	
			10:13::07	73.507	RB	39.4	
				73.535		40.8	
				83.542	+10	40.3	
				93.553	+20	40.3	
			10:38::21	98.716	Off O_2	40.2	
			10:43::22	103.746	On O_2	40.4	
			10:50::21	110.821	LB	40.4	
			10:52::27	112.794	RS	0.0	
4, 19, 28	90Jul19	SURD404	09:12::00	0.000	LS	0.0	Log says 1.8
			09:15::56	3.927	RB	116.9	
				4.333	RB	119.9	
				14.436	+10	120.2	
				24.352	+20	120.3	
				34.360	+30	120.3	
				44.367	+40	120.3	
			10:01::02	49.021	LB	120.3	
			10:04::42	52.686	R30	30.4	Log notes say "R27," which is without the water offset.
			10:06::48	54.803	L30	30.4	
			10:08:12	56.216	RS	0.0	
			10:11:15	59.279	LS	0.0	
			10:11:42	59.731	R43.6	43.6	
				59.805		43.6	
				59.827		42.4	
			10:12::01	60.223	RB	40.4	
				70.232	+10	40.2	
				80.240	+20	40.2	
			10:36::33	84.759	Off O_2	40.2	
			10:41::31	84.748	On O_2	40.2	
			10:48::32	96.778	LB	40.2	
			10:50:01	98.242	RS	0.0	
16, 18, 22	90Jul19	SURD405	12:05::50	0.000	LS	0.7	
			12:09::51	3.946	RB	116.1	
			12:12::14	6.411	RB	120.1	
				16.419	+10	120.0	
				26.425	+20	120.0	
				36.440	+30	120.1	
				46.446	+40	120.1	
			12:54:52	49.053	LB	120.0	
			12:58:27	52.610	R30	31.0	
				52.662		29.7	
			13:00::32	54.734	L30	29.7	
			13:01::45	55.888	RS	0.0	
			13:05::00	59.124	LS	0.0	
			13:05::27	59.587	R40	40.2	
				69.682	+10	40.2	
				79.889	+20	40.1	

Dive profile extract, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			10:06::05	66.492	R30	30.9	Log notes say "R27,"
			10:08::20	66.624	L30		which is without the
			10:09::35	69.854	RS	0.0	water offset.
			10:12::40	73.049	On O_2; LS	0.1	
			10:13::07	73.507	RB	39.4	
				73.535		40.8	
				83.542	+10	40.3	
				93.553	+20	40.3	
			10:38::21	98.716	Off O_2	40.2	
			10:43::22	103.746	On O_2	40.4	
			10:50::21	110.821	LB	40.4	
			10:52::27	112.794	RS	0.0	
4, 19, 28	90Jul19	SURD404	09:12::00	0.000	LS	0.0	Log says 1.8
			09:15::56	3.927	RB	116.9	
				4.333	RB	119.9	
				14.436	+10	120.2	
				24.352	+20	120.3	
				34.360	+30	120.3	
				44.367	+40	120.3	
			10:01::02	49.021	LB	120.3	
			10:04::42	52.686	R30	30.4	Log notes say "R27,"
			10:06::48	54.803	L30	30.4	which is without the
			10:08:12	56.216	RS	0.0	water offset.
			10:11:15	59.279	LS	0.0	
			10:11:42	59.731	R43.6	43.6	
				59.805		43.6	
				59.827		42.4	
			10:12::01	60.223	RB	40.4	
				70.232	+10	40.2	
				80.240	+20	40.2	
			10:36::33	84.759	Off O_2	40.2	
			10:41::31	84.748	On O_2	40.2	
			10:48::32	96.778	LB	40.2	
			10:50:01	98.242	RS	0.0	
16, 18, 22	90Jul19	SURD405	12:05::50	0.000	LS	0.7	
			12:09::51	3.946	RB	116.1	
			12:12::14	6.411	RB	120.1	
				16.419	+10	120.0	
				26.425	+20	120.0	
				36.440	+30	120.1	
				46.446	+40	120.1	
			12:54:52	49.053	LB	120.0	
			12:58:27	52.610	R30	31.0	
				52.662		29.7	
			13:00::32	54.734	L30	29.7	
			13:01::45	55.888	RS	0.0	
			13:05::00	59.124	LS	0.0	
			13:05::27	59.587	R40	40.2	
				69.682	+10	40.2	
				79.889	+20	40.1	

Dive profile extract, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
			13:30::30	84.631	Off O_2	40.1	
			13:35::30	89.616	On O_2	40.0	
			13:42::33	89.638	LB	40.0	
			13:44::45	98.904	RS	0.0	
4, 7, 29	90Jul24	SURD406	09:52	0.000	LS	0.0	
			09:56	4.006	RB	117.0	
			09:58::46	6.234	RB	120.1	
				16.241	+10	119.9	
				26.255	+20	120.0	
				36.264	+30	120.0	
				46.276	+40	120.0	
			10:41::38	49.107	LB	120.0	
			10:45::03	52.530	R30	33.8	
				52.582		32.5	
			10:47::15	54.742	L30	30.1	
			10:48::27	55.956	RS	0.0	
			10:51::41	59.191	On O_2; LS	0.0	
			10:52::10	59.675	RB	40.5	
				59.860		39.5	
				60.156		40.5	
				70.166	+10	40.1	
				80.176	+20	40.1	
			11:17::14	84.748	Off O_2	40.0	
			11:22::13	89.733	On O_2	40.0	
			11:29::14	96765	LB	40.0	
			11:31::21	98.895	RS	0.0	
6, 8, 10	90Jul24	SURD407	12:12::21	1.418	LS	0.0	
			12:16::16	5.340	RB	116.9	
			12:19::04	8.147	RB	119.9	
				18.162	+10	120.0	
				28.179	+20	120.0	
				38.189	+30	120.0	
				48.195	+40	120.0	
				50.491	LB	120.0	
			13:04::57	54.047	R30	29.9	
			13:07	56.097	L30	29.9	
			13:08::06	57.205	RS	0.0	
			13:11::23	60.499	LS	0.0	
			13:11::55	61.037	RB	40.1	
				61.181		40.1	
				71.189	+10	40.0	
				86.073		40.0	
			13:36::58	86.096	Off O_2	39.9	
			13:41::58	91.103	On O_2	40.0	
			13:48::59	98.136	LB	40.0	
			13:51::06	100.240	RS	0.0	
5, 11, 30	90Jul26	SURD408	09:32::00	0.381	LS	0.0	
			09:35::53	4.275	RB	116.5	Handwritten time
			09:39::07	7.514	RB	120.0	

Dive profile extract, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks
				17.524	+10	120.1	
				27.531	+20	120.1	
				37.542	+30	120.1	
				47.584	+40	120.1	
			10:21::00	49.411	LB	120.1	Handwritten time
			10:24::42	53.125	R30	30.1	
			10:26::37	55.044	LB	30.1	
			10:27::54	56.347	RS	0.0	
			10:31::00	59.453	LS	0.0	Handwritten time
			10:31::27	59.907	RB	36.7	Handwritten time
				59.923		40.2	
				59.951		42.5	
			10:31::31	59.979	R43.6	43.6	
			10:31::32	60.079	R40	40.9	
				70.134	+10	40.0	
				80.148	+20	40.0	
			10:56::30	84.955	Off O2;	39.9	
			11:01::28	89.962	+30; On O_2	39.9	
			11:08::35	97.079	LB	39.9	
			11:10::31	99.016	RS	0.0	Computer says 0.1
12, 26, 27	90Jul26	SURD409	12:21::22	21.983	LS	0.0	
			12:25::16	25.986	RB	116.8	
			12:27::56	28.571	RB	120.1	
				38.571	+10	120.1	
				48.584	+20	120.1	
				58.598	+30	120.0	
				68.604	+40	120.1	
			13:10::25	71.013	LB	120.1	
			13:14::00	74.490	R30	30.3	
			13:16::04	76.564	L30	30.3	
			13:17::20	77.840	RS	0.0	
			13:20::37	80.979	LS	0.0	
			13:21::02	81.409	R40	40.2	
				91.416	+10	40.1	
				101.423	+20	40.1	
			13:46::08	106.519	Off O_2	40.0	
			13:50::06	111.508	On O_2	40.1	
			13:57::06	118.514	LB	40.1	
			13:59::07	120.526	RS	0.0	

Dive profile extract, Dives SURD401 through SURD409, 120 fsw/50 min, Sur-D/O_2

Divers	Date	Dive #	Clock Time	Elapsed time	Event	Diver P, fsw	Remarks

c. Medical report

The medical report for this group follows. Diver 17 had neurological decompression sickness beginning 50 minutes after reaching surface and was treated successfully with USN Table 6.

NSN 7540-00-634-4176 600

HEALTH RECORD | CHRONOLOGICAL RECORD OF MEDICAL CARE

DATE | SYMPTOMS, DIAGNOSIS, TREATMENT, TREATING ORGANIZATION *(Sign each entry)*

NMRI EXPERIMENTAL DIVE SERIES
INDIVIDUAL DAILY DIVE RECORDS/TREATMENTS

NMRI PROTOCOL #: 90-02 DIVE #: 1 PRE RECTAL:
POST RECTAL:

PROFILE/BREATHING MEDIA: Sur-D O_2 120/50

MENTAL STATUS: N.

PUPIL SIZE: N. REACTIVITY: Brisk to A+L R+L.

REFLEXES: ANKLE Brisk + Equal

PATELLA "

BRANCHIORADIALIS "

BICEPS "

TRICEPS "

RECENT HISTORY/FITNESS TO DIVE

DATE & TYPE LAST DIVE: 17 July 90. Sur-D O_2 120/50 ABILITY TO CLEAR: VG + VG R+L

LUNGS (cough/wheeze): Lungs clear.

JOINT/BONE DISCOMFORT: None

LAST ALCOHOL CONSUMPTION: 24 MEDS: None SLEEP: Good.

REMARKS:
N/I relevant. FIT TO DIVE: YES/NO

TIME LEFT SURFACE: 1231 TIME REACHED SURFACE: 1400.

POST DIVE STATUS: (Time post dive/findings)
15 min post dive reported well.
50 min post dive developed hypoesthesia (L) forearm and hand. Tx'd on PT 6 + O2 extension at 30 fsw.

TREATMENTS: YES/NO (If yes, see reverse)

PATIENT'S IDENTIFICATION *(Use this space for Mechanical Imprint)*

RECORDS MAINTAINED AT: SOB NMRI DMD BETHESDA MD.

NSN 7540-00-634-4176 600-

HEALTH RECORD	CHRONOLOGICAL RECORD OF MEDICAL CARE

DATE | SYMPTOMS, DIAGNOSIS, TREATMENT TREATING ORGANIZATION *(Sign each entry)*

NMRI EXPERIMENTAL DIVE SERIES
TREATMENT CONTINUATION SHEET

NMRI PROTOCOL #: 90-02 DIVE #: 1

26 July 90. Surfaced from 120/50 Sur-D O_2 dive at 1400. Dive uneventful apart from light helmet which caused him to use (L) arm to hold helmet on shoulders. This gave him some discomfort over the (L) shoulder during the dive which was unchanged during decompression and still there on surfacing. Felt well on surfacing and remained so until 1450 when his (L) forearm and hand began to feel subjectively cold. Examined at 1455 when he had hypoesthesia of the (L) forearm and hand on clinical examination. Both sensation to pin-prick and light touch diminished with a sharp upper margin just below the elbow and with a "glove" type distribution. No other CNS disturbances elicited on full examination.

Put on O_2 and recompressed at 1518. In the last few minutes before recompression, cold sensation began to extend up arm. Had full relief within 10 min. at 60 fsw. TT6 on TT6 with a 5mg/6 00 min.

PATIENT'S IDENTIFICATION *(Use this space for Mechanical Imprint)*

RECORDS MAINTAINED AT: NMRI / Duke

extension at 30 fsw (this necessary because of the concurrent treatment of another diver.
Remained well and o/c of TT6 felt well.
Absolutely normal O/S.
Review mane.
Δ. Type 2 DCS.

R.R. Pearson
Surg. Capt. Rtd.

APPENDIX A.

Extract from original protocol for Project 90-02

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Protocol 90-02: Sur D Diving

This is an extract of the original protocol for Project 90-02. It does not include details irrelevant to the data such as watches, safety procedures, etc. The original page numbers are shown as P-1 and A-1.

Project Officer: J.W. Thorp, CAPT. MC, USN
Principal Investigator: E.D. Thalmann, CAPT, MC, USN

BACKGROUND, OBJECTIVES, RISKS, BENEFITS

The major purpose of the work done under this Work Unit is to obtain data that can be used to calculate decompression requirements for various diving operations. More information is needed to develop these calculations for situations in which surface decompression will be used. It is therefore necessary to develop operational procedures for simulating surface decompression dives with the Man-Rated Chamber complex (MRCC).

The purpose of this series of dives is to develop and perfect the techniques for doing surface decompression dives with the MRCC.

All diving will follow guidelines as published in either the Royal Navy or the U.S. _Navy Diving Manual. None of the procedures for compression or decompression will be experimental. However, there is some possibility that decompression sickness (DCS) will occur in some of the divers who participate in this process because it is known that DCS can occur even when diving is done strictly according to the U.S. Navy Diving Manual. Records will be maintained, therefore, so that the correlation of dive profile with incidence of DCS can be developed in conjunction with other data collected under this Work Unit.

There are anecdotal reports that there is a relatively high incidence of DCS among divers who have been compressed as "tenders" in these types of dives, possibly because their relative location in the chamber puts them at a depth that is not exactly in accordance with published tables, or because their skin is in contact with compressed air rather than water, or both. In order to minimize these risks, decompression will be modified compared to published tables such that "tenders" will breathe 100% oxygen during ascent.

There are only two ways in which this project would be considered experimental. (1) The use of oxygen breathing to protect tenders is not published as an approved practice, although the general practice frequently. is used during operational diving, and (2) records will be kept of any occurrences of DCS and may be used as the basis for designing future research. In all other regards, the diving is the same as would occur during operational diving conditions.

The risks of this study are essentially the same as those encountered by U.S. Navy Divers during operational conditions. They are detailed in Annex A.

The benefit of the study will be to develop techniques to gain information that will allow safer and more flexible diving procedures.

MEDICAL REQUIREMENTS AND RECORDS

Medical Examinations

Each diver will be physically qualified in accordance with MANMED 15-316. In addition, each diver will have had a detailed neurologic examination within 1 year and neuropsychologic testing within 3 years.

Pre-Dive Screening

Divers will have vital signs recorded within 1 week of the beginning of the

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dive series and entered on the SF-600 (Annex K1). These need to be repeated only after injury or illness. Grip strength will be recorded at this time.

On the day of each dive, each diver will be interviewed by the DWMO. The results of pre-dive neurological screening, any history pertinent to the diver's fitness to dive on that day, and whether or not he is fit to dive that day will be noted on the SF-600 - Experimental Dive Series: Individual Daily Dive Records/Treatments (Annex K2A, K2B).

Post-Dive Screening

Each diver will be interviewed by the DWMO at 30 min, 2 - 3 hours, and 12 - 24 hours after the dive. The DWMO will make a working file SF-600 entry stating the dive profile (depth/time, time reached surface) and the presence or absence of any injury. If no dive-associated problems occur, only a single entry after the last interview is required.

Alcohol and Medications

To avoid masking the symptoms of DCS, no subject will consume more than 2 ounces of alcohol within 24 hours before or after any dive. Each diver will notify the DWMO of any medication (prescription or nonprescription) consumed within 24 hours before any dive.

External Ear Prophylaxis

Otic Domeboro will be used for prophylaxis against otitis externa during wet dives. Prophylaxis will be administered after each wet exposure. All prophylaxis will be timed and logged in the dive log by the DWS or his representative. Application procedure is as follows: tilt head to side and fill ear canal gently with solution; retain solution in ear canal for 5 minutes, then tilt head to other side and drain canal; repeat for other ear.

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OPERATIONAL ASPECTS

Chamber Configuration

Dives will be conducted in "D" chamber with concurrent pressurization of "R" chamber. "A" and "I" chambers will be linked to be used as treatment chambers if needed for any single diver in whom it becomes apparent that recompression therapy is needed while "D" and "R" chambers are still being used for decompression according to the U.S. Navy Diving Manual. Surface Decompression will be conducted in

"R" chamber. If a need for hyperbaric treatment develops after the end of the dive, treatment will be in "R" chamber with O" chamber as the outer lock.

Pre-Dive Setup

All chambers of the MRCC will be set up in accordance with the OPs. Before each

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dive day, the DWS and DWO will review all outstanding MAFs, RECs, and the Red Tag Log.

Post-Dive Shutdown

At the end of each dive all chambers that were used will be cleaned and made ready for the next dive. "R" and "0" chambers, or, if necessary, "A" and "I" chamber lineups will be verified for use as treatment chambers. All breathing apparatus will be properly cleaned and dried.

Chamber Gas Supply

For all chambers, the Emergency Breathing Gas will be air; the Treatment Gas will be oxygen. All breathing gas during the dive(s) will be air. There will be three 80-cubic feet stand-by scuba bottles attached to the inside of the "D" chamber igloo. Each will be charged with air to 3000 PSIG before each diving day. These bottles will serve as emergency gas in the event of a catastrophic loss of air to the MRCC.

Gas Storage Requirements

All air flasks will be charged to a minimum of 3000 PSIG before each dive day. No less than 15,000 SCF of oxygen will be in storage before the Dive Series begins.

BIBS Configuration

For all chambers, oxygen will be provided to the BIBS treatment header and air will be provided to the emergency header. Each chamber will have six (6) masks hooked to the BIBS emergency header.

Divers Gas System Gases

The divers' gas system will be lined up in accordance with OP 12.2.1. The underwater breathing apparatus will be either AGA full face masks, Superlite 17s, or Mk-1 masks. Breathing gas will be air.

Hotel Functions

Chamber Complex Cleanliness

The wet pot will be drained and cleared of standing water at the end of each dive week. All 5 chambers and the wet pot chamber will be thoroughly cleaned once a week with non-ionic detergent (NID).

Sanitary Tanks/Water Supply

The sanitary system (commode, sink, and shower) will be thoroughly cleaned with NID at the end of each day it is used. If potable water is needed, the potable water system holding tanks will not be left stagnant for more than 48 hours.

Environmental Control

Oxygen Partial Pressure and/or Percentage Limit and Control

The automatic Oxygen Make-up System (OMS) will be used. Oxygen will be monitored utilizing Beckman 755 O_2 Analyzers. Additionally, portable O_2 electrode monitors will be in "A", "D", and "R" chambers. The normal limits of chamber O_2 concentrations will be between 20.5%. and 21.5%. If the O_2 concentration falls below 20.5%, follow OP-10 to add O_2 via the bypass of OMS-14 until a level of 21.0% is reached; O_2 add should stop at this point to prevent overshoot. If O_2 exceeds 21.5%, but is not above 25% no action is required, as the chamber occupants will breathe down the O_2 level. Follow EP-1 when the O_2 level exceeds 25% and use another chamber to facilitate a vent. If a vent cannot be accomplished, then the dive must be aborted.

If the O_2 reaches a partial pressure of 0.16 ATA or less, all dry chamber occupants will don the emergency BIBS mask and EP-2 will be followed.

Carbon Dioxide Partial Pressure Limits and Control

Chamber CO_2 levels are a function of blower RPM, CO_2 canister absorption capacity, and CO_2 production by the divers. No action regarding CO_2 absorption is needed until the chamber $ppCO_2$ exceeds 7.6 mmHg (1.0% sev), at which point the following actions will be taken:

If the blower speed is adequate and chamber $ppCO_2$ exceeds 7.6 mmHg, but is less than 11.4 mmHg for a period of two hours, the canister will be changed. If the chamber $ppCO_2$ exceeds 11.4 mmHg at any time during the two-hour period, the canisters must be changed immediately.

Inert Gas Limits and Control

Not Applicable

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Surface Decompression Dives

Schedules

The following schedules will be used (All depths refer to chamber depth corrected for depth offset related to diver location in the wet pot.)

U.S. Navy Tables

Surface Decompression on Air

	DEPTH	BOTTOM TIME	SCHEDULE
GROUP 1	60 fsw	180 min	60 fsw / 200 min
GROUP 2	120 fsw	50 min	120 fsw / 60 min

Surface Decompression on Oxygen

	DEPTH	BOTTOM TIME	SCHEDULE
GROUP 3	60 fsw	180 min	70 fsw / 180 min
GROUP 4	120 fsw	50 min	120 fsw / 60 min

Royal Navy Tables

Surface Decompression on Air

	DEPTH	BOTTOM TIME	SCHEDULE TIME
GROUP 5	18 MSW (60 fsw)	170 min	170 min
GROUP 6	36 MSW (120 fsw)	50 min	50 min

Schedule Modification

The dive profile will follow the manual except for the following modifications:

1) Inside diver tenders will breathe oxygen through the BIBS (held, NOT

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strapped in place) as follows:

a. If water stops are required, he will breathe 100% oxygen commencing at the first stop which is 60 fsw or shallower.
b. If no water stops are required, 100% oxygen will be breathed during ascent when a depth of 60 fsw is reached.
c. On 60 fsw dives, tenders will begin breathing 100% oxygen during the last 20 min at depth and during ascent.
d. For diver tenders in Group 6 (Royal Navy tables deeper than 60fsw) the tender will breathe 100% oxygen for one-half of the time spent in surface decompression - time to be arranged by the DWO.

2) If DCS occurs, modification of subsequent dives will be:

a. If two or more divers experience Type I DCS, subsequent dives at that depth will use the same decompression schedule but will have the actual bottom time decreased by one interval of time as listed in the respective Table.
b. If any diver experiences Type II DCS, subsequent dives at that depth will use the same decompression schedule but will have the actual bottom time decreased by two intervals of time as listed in the respective Table

3) Surface decompression on air with U.S. Navy procedures will have the surface interval begin upon leaving the last water stop. Ascent to the surface will be at 60 fsw/min and descent to the first chamber stop should take 30 sec. The time from leaving the last water stop until completing descent to the first chamber stop will always be exactly five minutes.

4) For surface decompression on oxygen with U.S. Navy procedures, the surface interval will be as described above except that the ascent time from the last water stop to the surface will be one minute.

5) When using Royal Navy surface decompression procedures, depths will be converted to fsw as follows:

MSW	FSW
36	120
18	60
15	50
12	40
9	30
6	20
3	10

There are no water stops. Ascent to the surface is at a rate of 60 fsw/min and descent to the first chamber stop should take one min. The total elapsed time from leaving the bottom and beginning descent to the first chamber stop will be four minutes since the Royal Navy procedure includes descent time to the first chamber stop as part of the surface interval.

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Diver Fitness and Participation

Divers will make no more than two dives per week with a minimum of 72 hours off between dives. No systemic drugs except antibiotics will be allowed unless cleared by the DWMO and DWO. Each diver will consume no more than 2 oz of alcohol during the 24 hr before he dives.

Divers will be interviewed each morning by a DWMO to verify fitness to dive. After completion of each dive, the DWMO will interview each diver within 30 min, 2 - 3 hr, and 12 - 24 hr after the dive.

Treatment of DCS will be in accordance with the U.S. Navy Diving Manual.

During each dive, there will be 3 divers in water plus 1 inside tender.

In Water Gear

All divers in water will wear a demand UBA and full 1/4" wet suits. Water temperature will be adjusted as follows, based upon total dive time:

Less than 140 min	60° F
140 - 360 min	65° F
More than 360 min	70° F

In Water Exercise

In water exercise will be performed on a cycle ergometer at 75 watts. Intermittent exercise will be done for approximately one-half of the total bottom time (10 minutes on bike alternating with 10 minutes off bike). If necessary, the last exercise/work period will be modified to ensure that all divers in the wet pot have equal amounts of time in exercise and at rest. Exercise will stop at least 2 min before ascent begins.

Travel Rates and Recording

All depths are diver depth. When all divers are dry, this will be chamber depth. When some divers are wet, this will be depth of the wet diver(s). For depth of wet divers, the depth offset to compensate for the actual diver depth below the wet pot surface will be added to chamber depth. Depth offset is the distance from the surface of the wet pot chamber/water interface to a point six feet above the grating at the bottom of the wet pot.

Compression rate will be as close to 30 fsw/min as possible. The investigator must be informed if the time to reach bottom is not within ±30 sec of the time calculated assuming a rate of 30 fsw/min.

Decompression rate will be IAW the U.S. Navy Diving Manual, and will be recorded on an x-y plotter pressure plot. Each plot will be labeled with date and time and given to the investigator.

During compression and decompression all times will be logged to the second. Time of reaching and leaving depth will also be recorded to the second.

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Diving Procedure

Divers will be hatted while sitting on the side of the wet pot, and complete communications and breathing check will be accomplished. Divers will then be unhatted and compression of "D" and "R" chambers to depth will be completed at 30 fsw/min. If any diver is unable to clear or otherwise tolerate compression, "O" chamber will be compressed to meet "D" and "R" chambers, lock out the affected diver, and then continue compression of "D" and "R" chambers to depth. The divers will be hatted and enter the wet pot with helmets awash. When all divers are in the water, they will descend in unison and the depth offset will be entered into the profile-recording computer.

Two divers will pedal the cycle ergometer for 10 minutes and then stand at rest for ten minutes. The other diver(s) will pedal during the rest period of the first two divers. If necessary, the last exercise/work period will be modified to ensure that all divers in the wet pot have equal amounts of time in exercise and at rest. This process will continue until 2 minutes before ascent.

Divers will remain at the bottom of the wet pot when decompression begins. Decompression will be IAW the U.S. Navy Diving Manual. During ascent, if any diver is stricken with pain or other signs or symptoms of DCS or AGE, the ascent will be stopped. One tender will be locked in via "I" and "A" chamber (two tenders if the stricken diver has been an inside tender), and the stricken diver will be transferred to "A" chamber for treatment of a "serious symptom DCS." Decompression will continue after the personnel transfer. If more than one diver is stricken during ascent, all divers will be treated by use of "D" and "R" chambers; in this event, an additional tender may need to be locked in through "O" chamber, at the discretion of the DWO.

Delays in ascent for either suspected DCS or mechanical problems will be handled IAW the U.S. Navy Diving Manual.

As chamber depth reaches 4 fsw, all divers will leave the bottom of the wet pot in unison. At that point the depth offset will be set to zero fsw on the profile-recording computer. At the surface, an additional tender will enter "D" chamber to help with the undressing and to serve as a tender during surface decompression. All wet divers will exit the wet pot, sit on the rim and be unhatted. They will then be undressed. After a surface interval as described above for the respective dive profile, the chamber phase will be accomplished by use of "R" chamber.

If any diver experiences symptoms of oxygen toxicity during surface decompression with oxygen, treatment will be IAW the U.S. Navy Diving Manual.

After surface decompression, all divers will be closely observed for 10 minutes while in the immediate vicinity of the chamber. Each diver will be interviewed by the DWMO at 30 min and 2 - 3 hr after surfacing, and must remain in Building 53 until the 2 - 3 hr interview is complete. Divers must remain within 2 hr travel time (by automobile) of Building 53 until the 12 - 24 hr interview is completed, generally the morning after completion of the dive.

DIVING MEDICAL PROCEDURES

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Barotrauma

All divers will be compressed in "D" and "R" chambers with one dry tender and three wet divers. Barotrauma during descent will be managed as follows: for a diver's first hold, "D" and "R" chambers will be decompressed 3-5 ft. If the condition fails to resolve, the diver will be decompressed to the surface in "O" chamber. If the condition resolves, compression will be resumed. For the second hold, "D" and "R" chambers will be decompressed 3-5 ft and the diver will prepare to exit. If the condition resolves, compression will resume. For the third hold, "D" and "R" chambers will be decompressed 3-5 ft and the affected diver will be decompressed to the surface in "O" chamber. All affected divers will be examined by the DWMO within 30 minutes of reaching the surface. The DWMO will make the appropriate SF-600 health record entry noting the presence or absence of any injury.

Oxygen Toxicity

The DWMO will be notified for any symptom suspected of being central nervous system oxygen toxicity. Oxygen toxicity will be managed IAW the U.S. Navy Diving Manual.

Decompression Sickness

Treatment will be in accordance with Chapter 8 of the U.S. Navy Diving Manual.

Omitted Decompression

Omitted decompression will be treated in accordance with the U.S. Navy Diving Manual.

Diver Illness or Injury

The DWMO will be notified of any suspected cases of diver illness or injury.

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ANNEX A
SURFACE DECOMPRESSION DIVING

Background

The major purpose of the work done under this Work Unit is to obtain data that can be used to calculate decompression requirements for various diving operations. More information is needed to develop these calculations for situations in which surface decompression will be used. It is therefore necessary to develop operational procedures for simulating surface decompression dives with the MRCC.

The purpose of this series of dives is to develop and perfect the techniques for doing surface decompression dives with the MRCC.

All diving will follow guidelines as published in either the Royal Navy or the US Navy Diving Manual. None of the procedures for compression or decompression will be experimental. However, there is some possibility that decompression sickness (DCS) will occur in some of the divers who participate in this process because it is known that DCS can occur eve n when diving is done strictly according to the US Navy Diving Manual. Records will be maintained, therefore, so that the correlation of dive profile with incidence of DCS can be developed in conjunction with other data collected under this Work Unit.

There are anecdotal reports that there is a relatively high incidence of DCS among divers who have been compressed as "tenders" in these types of dives, possibly because their relative location in the chamber puts

them at a depth that is not exactly in accordance with published tables, or because their skin is contact with compressed air rather than water, or both. In order to minimize these risks, decompression will be modified compared to published tables such that "tenders" will breathe extra 100% oxygen compared to the amount required by the table.

There are only two ways in which this project would be considered experimental.

(1) The use of oxygen breathing to protect tenders is not published as an approved practice, although the general practice frequently is used during operational diving, and

(2) records will be kept of any occurrences of DCS and may be used as the basis for designing future research. In all other regards, the diving is the same as would occur during operational diving conditions.

Methods

No diver will make more than two dives per week with a minimum of 72 hours off between dives. No systemic drugs other than antibiotics will be allowed unless approved by the investigator. The diver will not consume more than 2 oz of alcohol during the 24 h before any dive he makes.

Dive profiles will be selected by the investigator in order to schedule six groups of dives as follows:

According to the US Navy Diving Manual:

Relatively shallow (about 50 fsw) for maximum bottom time

Surface Decompression on Air **GROUP 1**

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Surface Decompression on Oxygen **GROUP 2**

Relatively deep (about 160 fsw) for maximum bottom time

Surface Decompression on Air **GROUP 3**

Surface Decompression on Oxygen **GROUP 4**

According to Royal Navy Diving Manual

Relatively shallow (about 50 fsw) for maximum bottom time

Surface Decompression on Air **GROUP 5**

Relatively deep (about 160 fsw) for maximum bottom time

Surface Decompression on Air **GROUP 6**

For each dive there will be 2 to 4 divers in the wetpot and 1 tender in the upper part of D chamber. All divers will breathe air. Divers in the wetpot will wear a demand UBA and full 1/4" wet suits. Water temperature will be adjusted as follows according to bottom time:

<140 m	60° F
140 - 360 m	65° F
>360 m	70° F

The divers in the water will spend alternating 10-m periods either at rest or working on a cycle ergometer at 100 watts.

All depths recorded will be WET DIVER depths. During immersion, the depth offset to compensate for the actual diver depth below the surface of the wetpot will be added to chamber depth to get diver depth. Depth offset is the distance from the surface of the wetpot chamber/water interface to a point six feet above the grating at the bottom of the wetpot.

Compression rate will as close to 30 fsw/m as possible. The tolerance for reaching depth is within ±30 s of the time required based upon travel at exactly 30 fsw/m. Divers who might have trouble clearing may be compressed fully dressed but unhelmeted, and then don helmets and enter the water as soon as the MRCC is compressed to the planned depth. Travel during decompression will be according to the Manual, and appropriate for the Group designation of the dive.

During decompression tenders will breathe extra 100% oxygen supplied through the Built In Breathing System (BIBS) compared to the amount of 100% oxygen required by the normal dive profile.

During compression and decompression, all times will be logged to the second. Time of reaching and leaving depth will be recorded to the second.

After decompression is complete, divers will exit the MRCC. They will stay on the operations floor until released by the Diving Officer.

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Dive log entries will include the computer file name, ascent and descent times to the second, and barometric pressure before and after each dive and at 3-hour intervals during the dive. The chamber depth and diver depth for all dives will be recorded and stored by a computer either once a minute or on a depth change greater than 2 fsw. Computer file names will be according to the following format:

SURDYXX.PRO

SURface Decompression diving

Y Group Number in Arabic Numeral (1 - 6)

XX Sequence of dive in this protocol - first dive is 01

After completion of the dive series all files will be transferred to magnetic tape, cataloged and stored permanently.

Risks and Benefits

The risks of this study are essentially the same as those encountered by US Navy Divers during operational conditions. They include:

a. There may be damage to the ears, sinuses, lungs or any enclosed, air-filled space in the body during compression (squeeze) or decompression (reverse squeeze).

b. During decompression there may be tissue damage with passage of bubbles into the circulation (Arterial Gas Embolism) that can cause damage to any organ, including the brain.

c. High pressures of oxygen can cause damage to the lungs or brain, but this risk is minimized by limiting the total exposure to levels that are below those allowed by official guidelines.

d. Divers may develop either Type I or Type II DCS.

e. Other known risks of working in hyperbaric chambers include the risk of fire, contamination of the breathing gas, failure of life support systems, and mechanical injuries from equipment.

The risk that any of these or other diving-related injuries will occur is no greater than it would be if the divers were engaged in diving under operational conditions. Medical equipment and medical technicians and physicians will be available at the chamber at all times to provide appropriate treatment if any of these untoward events does occur. In addition, all operation of the MRCC will be in accordance with applicable regulations and supervised and performed by trained and qualified personnel.

Treatment of any suspected cases of DCS will be conducted according to the procedures outlined in Chapter 8 of the US Navy Diving Manual. Divers who experience Type I DCS may resume diving in one week after completion of a treatment, if found fit to dive by the DMO. Divers who experience Type II DCS will not dive for a

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minimum of 14 days and will resume diving only on the recommendation of a DMO who is not an Investigator in this study.

Two specific risks must be addressed: arterial gas embolism and severe DCS. Both have been known to occur randomly without regard to depth/time profile, and both pose a risk of disqualification from diving. The risk of permanent injury is small based upon previous experience.

Arterial gas embolism (AGE) will occur for no apparent reason after breathing gas at an increased ambient pressure for any period of time. By limiting the maximum ascent rate to 60 fsw/m to eliminate the possibility of uncontrolled ascent and ensuring before the dive that divers have no signs of pulmonary congestion, the possibility of AGE will be minimized. If AGE does occur, rapid treatment according to standard US Navy procedures has been successful to alleviate all symptoms in the vast majority of cases. However, even if complete resolution is obtained, disqualification from diving may be required depending upon the diver's past history and the rapidity with which symptoms resolve.

The possibility that severe DCS will occur is related to the time/depth profile . In order to minimize the risk that any subject will develop significant injury from DCS, the dive profile will be strictly according to published tables as discussed earlier. The dive profile will be modified, however, if it appears necessary based upon events during the course of this project. If two or more divers develop Type I DCS, subsequent dives will be at a bottom time that is one interval shorter than the time that was used in preceding dives. If any diver develops Type II symptoms, then subsequent dives will be at a bottom time that is two intervals shorter than the time that was used in preceding dives.

The benefit of this study is to continue to gain information that will be used to calculate improved decompression schedules for use by the fleet so that the risk of injury to divers can be reduced while increased flexibility is available for planning diving operations.

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